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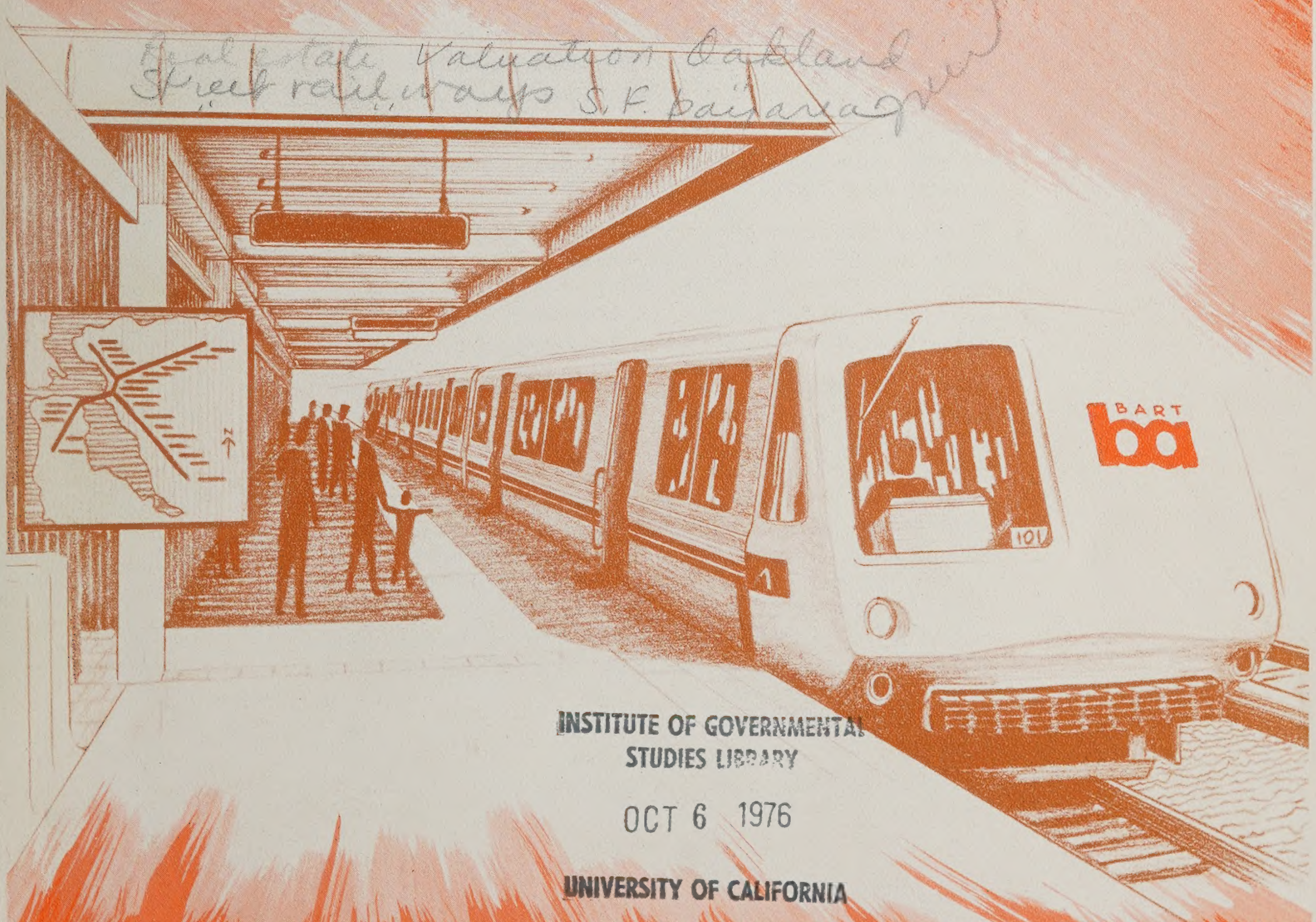
program

THE IMPACTS OF BART ON PROPERTY VALUES

A CASE STUDY OF THE ROCKRIDGE NEIGHBORHOOD

Real estate valuation Oakland
Street railways S.F. bay area



working paper

The BART Impact Program is a comprehensive, policy-oriented study and evaluation of the impacts of the San Francisco Bay Area's new rapid transit system (BART).

The program is being conducted by the Metropolitan Transportation Commission, a nine-county regional agency established by state law in 1970.

The program is financed by the U.S. Department of Transportation, the U.S. Department of Housing and Urban Development, and the California Department of Transportation. Management of the Federally-funded portion of the program is vested in the U.S. Department of Transportation.

The BART Impact Program covers the entire range of potential rapid transit impacts, including impacts on traffic flow, travel behavior, land use and urban development, the environment, the regional economy, social institutions and life styles, and public policy. The incidence of these impacts on population groups, local areas, and economic sectors will be measured and analyzed. The benefits of BART, and their distribution, will be weighed against the negative impacts and costs of the system in an objective evaluation of the contribution that the rapid transit investment makes toward meeting the needs and objectives of this metropolitan area and all of its people.

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THE IMPACTS OF BART ON PROPERTY VALUES A CASE STUDY OF THE ROCKRIDGE NEIGHBORHOOD

JANUARY 1976

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PREPARED FOR

U.S. DEPARTMENT OF TRANSPORTATION

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U.S. DEPARTMENT OF HOUSING AND URBAN DEVELOPMENT

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16. Abstract

This report describes BART's impact on the sales price of single-family houses in the Rockridge neighborhood. The Rockridge area of Oakland and its recent history are described as the hypotheses to be tested, and the general research strategy. Four specifications of an econometric model are discussed, and the variables used in the regression equations are identified. The before-after, the cross-sectional and the cross-sectional-longitudinal approaches are evaluated.

The Four models were used to test the null hypothesis that changes in sales prices of comparable houses did not correlate with distance to the BART station. This hypothesis could not be rejected in favor of the alternative suggesting that the price of houses located near the station increased relative to the price of comparable houses located farther away. In all cases, the estimated coefficients suggested that the price of houses located near the station had declined relative to the price of the more distant houses.

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A. S.

SUMMARY OF FINDINGS

The Alameda County Tax Assessor's machine-readable data base listing the characteristics of recently sold single-family houses was used to determine the Rockridge BART station's impact on the sales price of single-family houses. Four alternative econometric models were used to test the null hypothesis asserting that changes in sales prices of comparable houses did not correlate with distance to the BART station. This hypothesis could not be rejected in favor of the alternative suggesting that the price of houses located near the station increased relative to the price of comparable houses located farther away. In all cases the estimated coefficients suggested that the price of houses located near the station had declined relative to the price of the more distant houses. The estimated coefficients for the log-linear models were significant at the .10 probability level using a two-sided test and the null hypothesis was rejected in favor of the alternative suggesting that the station had caused a small relative decline in the sales price of houses. After controlling for the environmental effect of the station and the Grove-Shafter freeway along which the BART tracks run and using observations on the houses sold during 1973 and 1974, a difference of approximately 8% was found between the prices of the proximate and the more distant houses.

The depression in the price gradient appears to have occurred recently: the null hypothesis was not rejected when using data on the houses sold before 1973. The decline occurred during the period in which Rockridge residents became extremely concerned over the impact that BART related

development may have on the community. It appears that resident home-buyers favored the more distant houses while interest-owners, speculators and developers, did not find the station's proximity to be sufficiently attractive to cause them to compete for the land and drive up the sales price of houses.

INTRODUCTION

This paper describes the Rockridge BART Station's impact on the sales price of single-family houses. The Rockridge neighborhood and its recent history are described in the introduction. The hypotheses to be tested are listed and the general research strategy is described. A general description of the data base used in this study is also found in the introduction. The variables in the data base are described in the Appendix.

The second section of this paper presents the methodology to be used in the attempt to identify and measure the BART impact. Four alternative specifications of a general econometric model are discussed. The variables to be used in the regression equations are listed and described. The before-after, the cross-sectional and the cross-sectional-longitudinal approaches are evaluated.

The findings are presented next. The conclusions, along with their qualifications, are presented last.

1. Rockridge:

Rockridge is a North Oakland neighborhood covering approximately one square mile of land and housing a diverse population of some nine thousand people. Of the four thousand dwelling units, one-half are single-family houses. The remainder, in duplexes or small apartment buildings, do not disturb the single-family character of the residential areas. The boundaries of the study area are set on the north side by the Berkeley City limits and on the south-east by Broadway, a boulevard leading directly to the Oakland Central Business district. To the east, the start of the

Oakland Hills forms a vague boundary between Rockridge and the Chabot Canyon neighborhood. The more attractive houses are located on the east side of Rockridge. To the west of the neighborhood is a predominantly black residential area and the city blocks along this boundary of Rockridge form a transition zone between the white and black communities. City planners have expressed concern that the housing and environmental deterioration prevalent in this section may continue and spread eastward. The south-west boundary between Rockridge and the Temescal neighborhood is not clearly defined as no abrupt change occurs in demographic characteristics, land use patterns, and building types. Figure 1 shows the location of Rockridge within the Bay Area and Figure 2 describes the boundary of the study area.

College Avenue, a low-keyed commercial strip, runs through the center of Rockridge and marks the boundary between the generally attractive area to the east, on the foothills side, and the modestly priced housing in the flatlands to the west. The tram lines laid along College Avenue in the first decade of this century made suburban development in Rockridge possible. Subdivision started in 1903. Streets were laid out perpendicular to the tram lines and four thousand to six thousand square foot lots were staked out. Development rapidly extended outward from the College Avenue axis and by 1920, 57% of the houses now standing in Rockridge were completed. Only 14% of present dwelling units were built after 1930. The Alameda County Assessor's files in 1975 showed that only 15 single-family houses out of the two thousand were either built after 1960 or had been remodelled to such an extent that they were deemed to be "effectively" less than 15 years old. With the exception of several new stucco apartment buildings, very little recent residential construction has taken place.

Figure 1 - The BART System

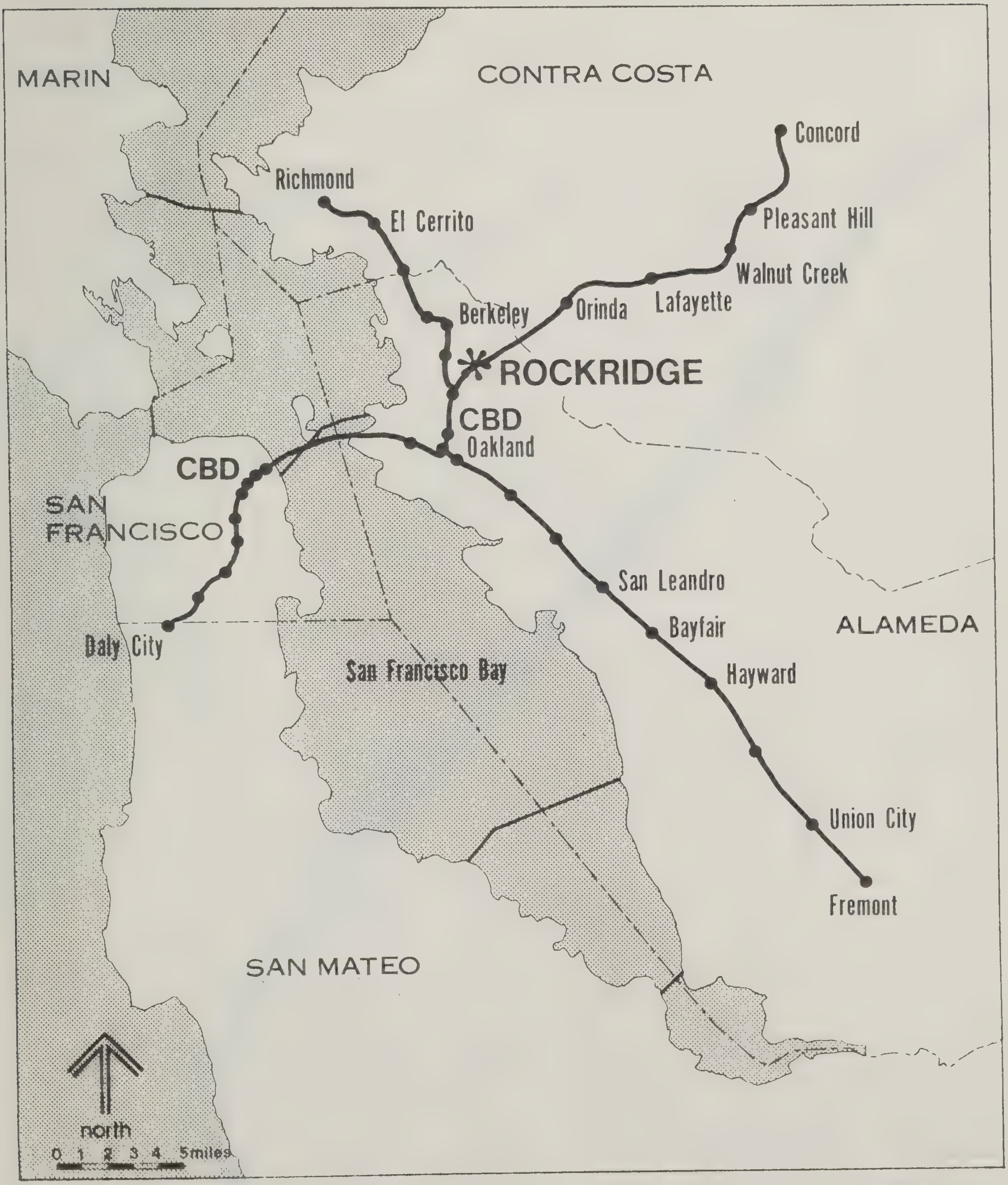

Figure 2 - The Rockridge Area

The Assessor's records indicate that only seven lots are "under-used" and can absorb an additional structure. New construction in Rockridge would involve the replacement of the old buildings. New high density construction would change the ambiance and the social structure of the community.

In 1913, when 82.4% of the new houses in Oakland were built to sell for under $2,500, those in Rockridge entered the $4,000 to $8,000 market. At its inception, Rockridge was an upper-middle income suburb and it was the tastes of these residents, their ability to purchase quality housing, and the care of the turn-of-the-century builders that set the predominant visual characteristics of the area. The large 'Tudor' or 'Norman' styled houses stem from this period. Rockridge, however, did not remain an exclusive community. Quarry workers, mostly of Italian descent, were housed in the south and east sides of Rockridge in stucco 'Spanish-American' bungalows. As a result of the varied housing stock, both professional and working-class people could and to some extent still can find suitable and affordable housing in Rockridge. In the mid-seventies, the broad choice of single-family housing options available in Rockridge was claimed as one of the neighborhood's major assets.

Rockridge retained its "small town" character until the mid-sixties when the six-lane Grove-Shafter freeway, with the Bay Area Rapid Transit (BART) lines running in its median strip, cut across the neighborhood with above-grade structures. College Avenue was bisected and the continuity of the shopping strip was broken. The quality of the Rockridge environment suffered, people were dislocated and further changes were expected.

Throughout the sixties, Oakland City officials were telling Rockridge residents that great changes were about to occur: BART, by making North Oakland a "transportation hub," would change its skyline. These forecasts

were presented in speeches made to various local community groups. In 1969 the predictions took on a more formal and therefore a more threatening tone. In 1969 the Oakland City Planning Department (OCPD) conducted a series of "round table discussions" with developers, economists, realtors, money lenders, architects, community representatives and public officials. These sessions were to yield an image of what was to happen in Rockridge. The Planning Department's report, Rockridge Station Area, presented the outcome of the deliberations. The forecasts of great changes were published and presented to the community:

> During the Planning Department's roundtable discussions on BART, some participants repeatedly emphasized the natural advantages of the Rockridge Station area for high-rise apartment development. Of all the BART stations outside the Oakland Central District, this area was described as the one most attractive to investors in residential building. Emergence of a high-density urban sub-center related to the station would be a dramatic alteration of the area's prevailing low-density character. Such an alteration appears necessary and desirable to capitalize upon the high transportation capacity of the BART system, to take advantage of the rejuvenating investment interest resulting from it. However, the implications of this kind of density change should be traced to avoid destruction of the area's basic residential appeal. [OCPD, 1969, p. 24]

Along with the forecasts came general policy guidelines. Areas for the initial concentration of high-density apartments were identified. It was suggested that the City provide incentives to encourage the assembly of small parcels of land. The main problem foreseen by the "round table" discussants was that due to pre-emptive development. Public intervention, however, could overcome this:

> Intensification of land use should occur in planned stages; rather sharp contrasts in allowable density would be justified [my emphasis], for example on R-80, high-rise apartment residential zone, abutting

> on R-50, medium density zone, to encourage development of the most suitable high density site first, while single-family areas would be preserved until a district market becomes evident for truly high-density development. Could this establish a system so that "transition" zoning would not create a belt of medium density apartments just beyond the initial high density district, thus freezing the holding capacity in that transition zone for the next 20 to 30 years? [OCPD, 1969, p. 28]

The main undesirable market response to BART feared by planners was pre-emptive development which would choke the growth potential by wasting land resources with two and three story apartment buildings. Public intervention was needed to assure that an efficient land use plan could emerge and an efficient plan was one which maximized the long run development potential. Should such policy succeed, then Rockridge and its BART station was seen to bring middle income residents back to Oakland, increase the tax base, increase the number of people who would enjoy the use of BART, and put an accent on the skyline of North Oakland. All this was feasible because BART improved the area's accessibility to the CBD's <u>and</u> because the neighborhood's quality was good enough to attract investors.

In 1971 a prospective developer announced his intentions to build a seven-story apartment slab and applied for the re-zoning of three single-family lots located near the station. Reaction to the proposal was mixed. One local group sought to "up-zone" the area within the potential development zone. Another group, the Rockridge Community Planning Council, sought a comprehensive plan for Rockridge, a moratorium on building permits for six months and an analysis of the social and economic consequences of BART-related development. The residents became acutely concerned with

the future of Rockridge. The potential developer lost interest and dropped his project. The Rockridge Community Planning Council developed a strong "grass-roots" organization and became a "council" to which sub-neighborhood organizations sent representatives. In 1973, the Rockridge Community Planning Council petitioned the Oakland City Officials for a land-use plan which reflected the interests of the Rockridge residents. They petitioned for a planning study which would determine the 'needs' of the neighborhood and the 'desires' of the residents. Joel Kotkin, writing in the Bay Guardian, describes the present and the expected future environment of Rockridge:

> Walk into Rockridge today, and you'll see one of Oakland's finest remaining neighborhoods. Single family houses, comfortable old brown shingle buildings, a bustling area of community-oriented shops along College Avenue. While the rest of Oakland gets increasingly segregated into poor, minority districts in the flatlands with middle-income white tract housing on the hillsides, this North Oakland neighborhood has kept its unique, integrated (80% white, 20% black) character. In fact, while Oakland's own 1969 planning study called "the majority" of the city's residential areas "dreary and uneventful," City Councilman George Vakasin admits Rockridge is "one of the few exceptionally good areas of the City."
>
> Walk into Rockridge five years from now, and you may be confronted by high-rise apartments, lots of banks and expensive specialty stores, parking garages and a population composed of transient, upper-middle-class secretaries and executives from San Francisco corporations who see Rockridge as just another bedroom community. Because, unfortunately for Rockridge, as well as being a unique community, it is a stop on the BART Concord-Daly City line. And that highly dubious honor opens it up to the developers, realtors, and new urban commuters who could destroy its fine small town atmosphere.
>
> Part of the grand scheme for the "new" Rockridge is a sparkling new image. The idea of the planners and developers is that Rockridge should follow the lead of San Francisco's Union Street, where an old neighborhood was transformed into a high-class commercial row accommodating transients of the monied sort, from society matrons to swinging singles. [Kotkin, 1973, p. 4]

Concern for the future quality of the neighborhood spread, citizen group activity intensified and the Oakland City Council yielded to their demand for an "in-depth" analysis of the social and economic consequences of BART-related development. Gruen + Gruen & Associates were commissioned to do the impact analysis and in 1974 the Oakland City Planning Department published the results in a report titled Alternatives for Rockridge. The preface of this report indicates a change in the attitude of the City Planners and the text starts by assuring the residents that the Planning Department "makes no recommendations as such." The report "sketches out alternative strategies which might be pursued to alter the course of events. . . . The alternatives are really concepts rather than proposals, and this report makes no attempt to recommend any one of them over the others." It also made clear that the City was not offering these alternatives to Rockridge. "These alternatives are posed as a basis for discussion, by people in Rockridge with City Officials." The five alternatives described the range of feasible land use plans for Rockridge. Under current conditions "it is possible that as many as 900 to 1,200 private-market multi-family units will be built in Rockridge over the first decade after BART impact" -- a 25% increase in the number of units presently in Rockridge. If development were encouraged then the impact could bring 1,400 new apartment units, 600,000 square feet of retail floor area and 300,000 square feet of office space: i.e., 14 ten-story apartment buildings with ten units per floor, a net increase in commercial space equivalent to 60-foot-deep strips along both sides of College Avenue extending half a mile on both sides of the BART station and three ten-story office buildings having 10,000 square feet per floor. This addi-

tion of approximately two million square feet of floor space, if valued at $30 per square foot, would increase the tax base by 60 million dollars, and the Oakland City Planners thought that

> The physical character of various sections would change significantly. . . . However, due to design controls, rehabilitation and various public improvements, the overall quality of the environment would generally improve. [OCPD, 1974, p. 77]

Local residents thought differently. Of the five alternatives, they accepted only the minimal change option. Citizen group leaders and representatives of the local Merchants' Association worked with the sympathetic Oakland City Planning Department to prepare a land use plan which would prohibit high-rise construction and help restore some of the lost quality of College Avenue. The plan was supported by most residents. The local realtors and interest-property owners, who once held dreams of a boom in North Oakland, did not publicly voice opposition. In December 1974, in front of a record audience, the Oakland City Council accepted the plan to down-zone Rockridge and a calm settled over the residential community. Figure 3 lists the key events leading to the rezoning of Rockridge.

2. The Hypothesis:

Although the controversy has been resolved for the time being, some interesting questions remain unanswered. Did the downzoning decision stop an imminent threat to the neighborhood? Was the belief in the great development potential held only by the city planners and the local realtors, or was this belief shared by housing suppliers to an extent sufficient to cause an increase in the competition for land located near the station and thereby cause its price to increase? Local residents appeared to have been unanimous in their opposition to the BART induced development potential because

Figure 3

Key Events Leading to the Rezoning of Rockridge

1956	Grove-Shafter Freeway route announced
1962	BART bond issue passed by public referendum
1965	Construction started on freeway and BART
1968	Publication of the first set of guidelines and forecasts for Rockridge (The Rockridge Station Area report)
1971	Request for rezoning to permit the construction of an 83-unit apartment slab near the BART station.
1972	Unsuccessful request for a six-month moratorium on building permits and formation of the Rockridge Community Planning Council (RCPC)
1973	Development of sub-neighborhood organizations and strong "grass-roots" support for RCPC
1973	Publication of the Gruen + Gruen Report
1974	Publication of the Oakland City Planning Department's report, Alternatives for Rockridge
1974	Land-use plan prepared by local residents, merchants and city planners
1974	Plan to "downzone" Rockridge accepted by City Council

they feared its environmental consequences. The tradeoff between a "destroyed neighborhood" and the windfalls due to the price increases usually associated with an emerging development potential were not explicitly made. Why? Did property prices not rise and therefore did the BART development potential not offer any benefits to the present home owners? Did the publicized development potential, by creating conflict and uncertainty regarding the future character and zoning of the neighborhood, reduce the market demand for houses located near the station and thereby reduce their sales price?

If, as predicted, the presence of the station was to alter the structure of the Rockridge housing stock, then we should be able to observe an increase in the sales price of the houses located near the station relative to prices of the more distant houses. Casual observation of the Rockridge market yields no indication that demand for houses near the station increased significantly more than it did for comparable houses located further away. It is possible that the forecasts of great changes in the station's vicinity made the more distant locations preferred by households. It is also possible that the strong citizen group reaction to potential development made housing suppliers cautious and kept them away from the station area. It is possible that the market demand and therefore the price of houses located near the station decreased. Prior to the examination of the data, we cannot say whether the station's net impact on prices was positive or negative.

The null hypothesis, asserting that changes in the sales prices of comparable houses did not systematically vary with distance to the BART station will be tested against alternatives suggesting that the prices did change across space. The direction of the relative price change is

not specified because we have no prior reason to believe that the net effect of the access change, the forecasts and the citizen group reaction on sales prices were positive or negative. A two-sided test of the null hypothesis is called for.

3. The Research Strategy

Every model used in this study rests on the assertion that BART, should it have an impact on sales prices, will have one which decreases in magnitude with distance from the station. The ideal method of finding and measuring the impact would involve an experiment in which identical houses located in different areas of Rockridge are sold during one time period. Analysis of the observed price differences would tell us the amount the buyers were willing to pay for proximity to the BART station. Such an experiment is, of course, not possible and we must make use of data coming from market transactions occurring at different points in time and involving houses with different attributes. Therefore, an econometric model must be designed which controls for the attributes that affect the sales prices and which tend to change with distance from the BART station. Because all parts of the study area are almost equally accessible to the region's centers of interest by transportation modes other than BART, it is possible to posit the following unspecified model: the sales price P_i of a house i is some function of its distance to BART d_i, a set of housing attributes $\underline{Q}_i$, and an error term E_i, which accounts for the apparently random variation in sales prices and for all the other housing attributes which affect the sales prices but are not included in $\underline{Q}_i$:

$$1. \quad P_i = f(d_i, \underline{Q}_i, E_i; \beta, \underline{\alpha}) \qquad i = 1, \ldots, n$$

The parameters β and $\underline{\alpha}$ describe the structural relationship between the attributes and the sales price of Rockridge houses. In order to estimate the magnitude of these parameters by the method of Ordinary Least Squares (OLS), a general model must be specified and the variables in the final equations must be transformed to yield a linear equation:

$$2. \quad (P_i) = c + \beta(d_i) + \sum_{j=1}^{L} \alpha_j (Q_{ji}) + (E_i) \qquad i = 1, \ldots, n$$

where:

(P_i) is the sales price in dollars of house i or some mathematical transformation of this variable.

(d_i) is the linear walking distance of house i to the BART station or some specified transformation of the measure.

β is the parameter describing the magnitude of the true relationship between distance and price.

(Q_{ji}) is the j^{th} control variable describing a relevant housing attribute. All attributes which affect the sales prices and are correlated with the distance variable are relevant.

α_j is the parameter describing the relationship between attribute Q_j and the sales price.

(E_i) is the error term due to apparently random fluctuations in sales price, due to mistakes in the gathering or recording of data and due to variables omitted from the equation.

Should the variables in the set $\underline{Q}$ completely describe all the attributes people consider when buying a house, the partial derivatives of the sales price with respect to each of the variables would describe the implicit prices people have paid for each attribute. The set of derivatives would constitute the "hedonic price index" for the housing attributes. The

index, an abstract construct, would describe the relative value the market has placed on each attribute. It would show the relative amount people have implicitly paid to have an extra unit of each attribute. Since our goal is to find out how much people have paid for proximity to the BART station and since we do not particularly care to know how they valued the other housing attributes, the set of variables in $\underline{Q}$ need not be complete. We include variables on the housing characteristics which affect sales prices and which vary with distance to the station. The effect of the omitted variables will be accommodated by the error term and their omission will not cause us to obtain "biased" estimates of the sought after parameter β.

If all the non-BART factors which are correlated with distance are included in the model, then the expected value of the OLS estimate of the distance parameter will describe the unique relationship between the price houses were sold for and their distance to the BART station. Because the control variables account for the price consequences of all the other relevant attributes, the finding of a non-zero distance parameter permits us to draw the inference that the presence of the BART station has had an effect on sales prices.

The accuracy of the estimated distance parameter depends not only on the extent to which other factors are controlled for but also on the exactness with which we can specify the true relationships among the factors, on our ability to transform the variables to yield a linear equation, and on the size and the quality of the available data base. Errors will be introduced as we attempt to construct a linear model by means of transformations and as proxy variables are introduced to account for relevant

factors on which data is unavailable. Furthermore, the state of the art does not permit us to say with certainty that the manner in which a set of housing attributes relate to sales prices is such and such. We recognize, at the outset of this endeavor, that the tools which are to be used to identify and measure the Rockridge BART station's impact on sales prices are rather blunt.

While we expect the access improvement to increase the attractiveness of houses located near the station, we realize that the conflict resulting from the forecasts of potential changes in the neighborhood may have deterred house-buyers. It is possible that no net price change has occurred. Discussions with local residents, realtors, and tax appraisors lead us to believe that the station, should it have caused a price change, has caused one that is most unremarkable. It appears that the null hypothesis is going to be hard to reject. I therefore propose to approach the Alameda County Tax Assessor's data with a set of plausible models and measurement techniques, rather than with a highly developed equation resting on a restrictive set of assumptions. This battering approach is acceptable given the present state of the art of measuring land use impacts. Professor Douglass Lee, Jr., [1973, Vol. 1, p. 68] has argued that there are really no a priori reasons to select any functional form as the "best predictor" of the system's impact on sales prices. If there is no reason to select any one functional form, then surely there is reason to use and to explore the implications of several plausible functional forms.

If the null hypothesis cannot be rejected by using any of the reasonable approaches, then we conclude that either no impact has occurred or that the statistical tests were not sufficiently powerful to detect the impact. If the tests prove to lack power, then nothing can be done about

it at this point in time because the data used in this study come from observations on all the last sales of Rockridge houses since March of 1968 and the size and quality of this, the best available, data base will not change until next year. Furthermore, should we be unable to detect any BART impact by using the best data available, then for policy purposes we conclude that no impact on sales prices has occurred. This conclusion rests on the belief that good policy is based on empirical evidence and not only on theoretical postulates.

4. The Data:

Indirect access was gained to the Alameda County Assessor's machine-readable files containing data on both the sales price of houses and their characteristics. Confidentiality requirements precluded direct access and limited the analyst to the use of the computer software available at the Assessor's Office. No information was sought and none was obtained on any identifiable house. All the summary statistics that were released have been scrutinized by the Assessor's staff to ensure the anonymity of each observation.

Data on some 140 variables is on file for approximately 600 observations on the most recent sale of each Rockridge house since March of 1968. Data on sales occurring before this data have not been recorded. Data on sales which occurred since this date but which are not from "the most recent" transaction are not on the machine-readable file and could not be used in this study.

The Assessor's estimate of the market value of the house, its roll value, replacement cost new, replacement cost less depreciation, replacement cost new of the garage, quality class of structure, degree of delayed

maintenance, quality of building, age of building, "effective age" of building computed after considering recent remodeling efforts and maintenance levels are some of the variables on which data is available. Described also are the physical attributes of the house such as the area of each floor, number of rooms, type of dining room, den, basement, number of bathrooms, number of fireplaces, type of garage, size of garage, type of exterior finish of the house, degree of pitch of the roof and architectural style. The lot dimensions are given along with the Assessor's estimate of the useable lot area. Categorical variables tell whether or not the appraiser deems the building's floor plan to be functional, the lot to be under-utilized or over-utilized by comparison with other lots in the area. The view potential of the lot and the extent to which it is exploited is described. The street the house is on is described and the extent of traffic on the street is given. The slope of the lot and of the street are given, according to three categories: flat, medium, steep. The site's access to schools, recreation facilities, shopping, freeways is assessed and variables describe whether or not the proximity is considered by the appraiseras a nuisance, as a convenience or as a detriment because it is non-existent. A "special problem" entry tells whether or not the appraiser believes BART to have increased prices of the property. No such entries were found in the Rockridge file, indicating that the appraisers believe that BART has not increased the market value of the Rockridge houses.

The sales price of the most recent transactions since March 1968 is recorded after an appraiser judges the sale to be a competitive market transaction. The age of the sale is given in the number of months since July 1975. The most recently sold house on which data is available

occurred in March 1975, and the oldest sale in March of 1968.

The walking distance from the BART station to the center of each city block was measured on maps obtained from the Oakland City Planning Department. The variable was entered as a "sub-neighborhood code." Because the number of values which could be coded in this manner was limited to 30, the distance variable was scaled to measure in units of 50 feet. The variable takes on values ranging from 6 to 42. No finer distance measure was possible given both the confidentiality requirement and the restrictions on the number of control cards.[1] The distance variable contains a stochastic term with an expected value equal to zero. The consequences of the inexact measure of distance to the station are discussed in the methodology chapter.

Appendix A lists and describes the variables in the Alameda County Assessor's machine-readable files.

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[1]At the time the file was prepared for my use and during the period that exploratory runs were made, the number of control cards could not exceed 130. Approximately 60 were used to generate the simplest regressions presented in this paper. Due to restraints on the appraisor's time, only one pass at the data was possible. The first and only regressions run are presented in this paper. This constraint in some cases mars the elegance of the equations but in no way reduces the import of the findings.

II. METHOD

The aim of this section is to present the logic and the assumptions needed to move from the unspecified model represented by equation 1 to a specified linear one as depicted by equation 2. It describes the relationships between the distance variables and the price of houses, the expected effect of the access improvement and of the environmental impacts. It discusses the alternative functional forms of the equation. Four alternative models are specified and their strengths and weaknesses are evaluated. The candidate control variables are presented next. The before-after, the cross-sectional and the cross-sectional-longitudinal approaches to the identification and measurement of the BART impact are discussed last.

1. The General Model:

It is reasonable to assume that people, before buying a house in Rockridge on which we have data, shopped around. It is also reasonable to assume that the sellers sought the maximum by setting an "asking price" which was in many cases higher than the one they finally accepted. It is reasonable to expect that the people who bought houses in Rockridge in the post-1968 period considered the effect BART might have on their real-income. Should the firm or household which bought for price P_i a house have had the option of buying a comparable house a small distance, ∂d, further away, at an expected price P_j, then the maximum premium it would have paid for the improved access brought about by BART is ∂P:

$$3. \quad \left.\frac{\partial P}{\partial d}\right|_{d_i} = \sum_{t=1}^{T_i} B_{ti}/(1+r_i)^t + E(\left.\frac{\partial P_s}{\partial d}\right|_{d_i})/(1+r_i)^{T_i}$$

and:

$$B_{ti} = \left.\frac{\partial Y_{Rti}}{\partial d}\right|_{d_i} \cdot F_{ti}(d_i) \cdot (1 + \left.\frac{\partial F}{\partial d}\right|_{d_i})$$

where:

T_i is the length of time household i expects to stay in the house.

B_{ti} are the benefits household i expects to gain during time period t by living one unit distance closer to BART. The expected benefits are a function of the household's perceived marginal cost of travelling to the BART station evaluated at distance d_i, the frequency with which it expects to use BART during time period t and the rate of change of the frequency with change of distance to the station.

r_i is the household's subjective rate of discounting future benefits.

$E(\left.\frac{\partial P_s}{\partial d}\right|_{d_i})$ is the price-gradient at d_i that the household expects will prevail at time T_i when it sells the house.

As potential buyers shop around and sellers seek the maximum bid by setting high asking prices, both groups develop a sense of the market. Buyers perceiving the BART mode to offer the greatest savings and considering most costly the trip to the station, will bid more than others for houses located close to the station. The amount sellers can capitalize

on this increase in demand depends on their ability to assess the buyer's intentions and preferences, on their patience, on the price the potential buyers expect to pay for more distant houses, and on the buyer's valuation of the difference in the access attributes of other acceptable and available houses.[2] If sellers are equally capable and buyers are consistent in forming expectations regarding the price they would have to pay for comparable more distant houses, then the emerging price-gradient will reflect at each point in space the individual household's maximum price-bid gradient and Equation 3 can yield three conclusions regarding the functional form of the model.

First, it is likely that a household, had it bought a more distant house, would use BART less frequently. BART's relative advantage over other modes of transport decreases with an increase in the total cost of travelling to the station. Even if all households have identical tastes, real-incomes and expectations, the emerging price gradient will flatten with distance from the station: the second derivative of price with respect to distance is positive. The rate of change in the price gradient due to the access improvement is not *a priori* determinable. It

[2] We can speculate on the magnitude of the maximum price-bid gradient of the rational head of household who plans to commute via BART 253 days a year, earns during his last hour of work \$6, can equilibrate his work-leisure time allocation, considers the walk to the station a total waste of time, uses a 15% discount rate on future benefits, considers a ten year planning horizon and walks to and from the BART station at a rate of 12,000 ft/hr. This economic man would perceive the annual savings associated with a 50 foot decrease in distance to the station to be:

$$S_{t=1} = 50\text{ ft/trip} \times \$6\text{/hr} \times 2\text{ trips/day} \times 253\text{ days/year} \div 12{,}000\text{ ft/hr} = \$12.65\text{/year}.$$

The present value of the ten-year stream discounted at 15% is \$73.03. Thus, the maximum premium that this otherwise rational man would be willing to pay for the closer of two otherwise identical adjacent houses on 50 foot wide lots is \$73.03!

depends not only on the characteristics of the home buyers but also on their number and the extent to which speculators, with steeper rent-bid schedules, competed for the BART location.[3]

Second, the amount people pay for proximity can be viewed as a premium added to the price they would have paid for the other housing attributes: the functional form of the relationship between the distance and the other housing attributes is additive. The amount a seller can gain due to an improvement in access attributes depends on the buyers' expected savings in travel costs and the price of comparable, more distant, houses. If a household considers two options and realizes that the monetary value of the future stream of savings due to reduced travel time would be x dollars greater should the closer one be chosen, then the household would be willing to offer x dollars more for the closer location regardless of the amount it is willing to pay for the other housing attributes. The household's valuation of the access attribute is independent of its valuation of the other components making up the housing bundle. From the viewpoint of the buyer, BART's impact on the access surface adds value to the house.

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[3] This argument for the flattening of the price gradient with distance can be bolstered by many others. 1) Owners of houses near the station are likely to be more aware of the BART potential and expecting large windfalls will be more patient than owners further away with smaller expectations. 2) Houses close to the station are more likely to be bought by speculators or developers who consider the sites potential use and the latent demand for apartments within easy walking distance from BART. Developers expecting to realize the sites' full potential and the associated profits will easily be able to outbid potential home-owners for the closest sites. 3) The rate of change in cost of travelling to BART is likely to decrease with distance to the station as "kiss and ride" replaces walking. 4) The identical tastes proposition is ridiculous; should competition for the BART location exist, people with less steep bid-price gradients are likely to live further away and by definition be willing to pay less for an extra unit of proximity to BART.

Third, because the gradient reflects each household's valuation in dollars of the real-income lost while travelling to the station, its expected frequency of using BART, its subjective rate of discounting future benefits and its thoughts about resale value; it is likely that people buying different kinds of houses are willing to pay different amounts to live closer to the station. Therefore, the price gradient across the different sub-markets is expected to differ in ways that are not determinable prior to the examination of the data.[4] These conclusions lead to the following non-linear model:

$$4. \quad P_i = \beta_1 d^{\beta_2} + G(\underline{Q2}_i, E_i; \underline{\alpha 2}) \qquad i = 1, \ldots, n$$

Where the first term on the right hand side of the equation describes the premium due to the change in the access surface. It describes the average implicit prices paid by the new owners and the magnitude of the two parameters may be different for houses with different characteristics. The second term contains the control variables which account for the effect on sales price of the other relevant housing attributes. It includes variables

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[4]The following are arguments for an empirical determination of the relationship between the BART premiums and the price of the other housing attributes. Upper and lower income people may on average be willing to pay more or less the same amount for BART proximity should their mortgage terms be equal. The lower income households buying houses with FHA insurance may face a mortgage ceiling whereas upper income households, using conventional loans, do not. The lower income households may have to buy outright the benefits of proximity whereas their wealthier counterparts may be able to spread the payments for the premium across time. This difference may make it easier for sellers of the better quality houses to capture a larger share of the buyer's future savings in transportation costs. Arguments countering this conclusion can easily be advanced. Speculators or developers considering conversion may enter the market for low quality houses on lots accessible to the station and thereby drive up the price of this kind of housing.

which account for the station's environmental impacts. Since this equation is non-linear, its parameters cannot be estimated by one pass with OLS and assumptions regarding the value of β_2 will have to be made.

The BART station changed more than the access surface and these side-effects may have a negative impact on sales prices. The freeway's and the BART system's impact on the physical environment can partially be controlled for by the categorical variable identifying properties deemed by appraisors to suffer from these consequences. The effect of expected changes in the future environment, due to a prevailing belief in BART induced development, will be picked up by the distance variable. Since BART is believed to be the cause of such changes, it is reasonable that people expect such development to occur first in the vicinity of the station. The fear of crowded streets and high rise neighbors is likely to attenuate with distance from the station and therefore the magnitude of any depression in the price gradient is expected to decrease with distance. Unlike the effect of the access change, the loss of neighborhood quality is likely to affect the household's valuation of the other components of its housing purchase and therefore the relationships between this price effect is expected to be proportional to the amount paid for the other housing attributes.

A discussion of the relationship between price and the control variables follows. We want to know the difference in the sales prices of comparable houses located at varying distances from the BART station. Since the houses on which we have data are not directly comparable, we have to account for the price differences attributable to other characteristics by means of control variables. Since the final equation must be linear in form, the specification of a non-linear relationship must be

accomplished by transforming the variables:

> It would be best if we could derive the conditions for the appropriate inclusion of variables in the model from some theory involving the characteristics of land use. Although we have grounds to treat the price/ accessibility relationship through various shapes (and can specify the assumptions behind each choice), there is no basis from which to assert whether the following control variables have an additive, multiplicative, or exponential effect on price. [Douglass Lee, Jr., 1973, Vol. 1, Part III, p. 96.]

Given that we do not have a theory describing how different housing attributes are implicitly priced, we can only speculate as to what is the best functional form for the control variables and then approach the data with alternative specifications. The additive form is chosen when we believe that differences in sales prices attributed to differences in one factor are independent of the other characteristics of the house. The additive form is chosen when we believe that the implicit price people have paid for an extra unit of some attribute is independent of the amount they paid for the other components of their housing purchase. The choice of the multiplicative form rests on a belief that price elasticities describe best the constant relationships between sales price and housing components. The multiplicative form is chosen when the difference in the amount of one attribute, or the presence of some characteristic, is believed to have a proportional effect on sales prices. We choose this form when we believe that the amount people would pay to have an extra unit of some component is proportional to the price they pay for the entire housing bundle.

It is likely that the true relationship is non-linear, that some control variables affect prices additively and others proportionally. The price difference attributable to features which can be added to a building are most likely to be independent of the amount paid for the other housing

attributes: the amount an owner can get for them is constrained by the cost to the buyer of installing an extra range, garage, or finished basement. The relationship between the implicit price paid for land and that paid for the improvements is certainly additive in some cases. Once the effect of neighborhood quality is accounted for, I have no reason to believe that the implicit price paid for an extra unit of land has anything to do with the improvement that is on it. This belief in the additive nature of the relationship is enforced by looking at the extreme case: If the improvement is uninhabitable, investors will buy the land and pay a price which has little to do with the nature of the improvement. This belief in the additive relationship between implicit price paid for land and that paid for the improvement is consistent with theory explaining urban land values as a function of commute costs.

The structural relationship between some characteristics and prices is multiplicative. Differences in neighborhood quality are likely to affect people's valuation of the other housing attributes and therefore have a proportional effect on sales prices. The age of sale variable, controlling for the effects of inflation, will have a multiplicative relationship to sales price. Many variables describing the quality of the house are also expected to have proportional effects on price. For example, the difference in sales price attributable to the level of maintenance, structural quality and presence of expensive finishes is likely to be proportional to the amount people pay for the other attributes such as floor area and number of rooms.

The choice of functional forms depends on which we believe best depicts the non-linear reality facing us. Because I have no theoretical basis for selecting one functional form over the other, I will, in keeping with the research strategy outlined earlier, use both.

In conclusion, the additive and multiplicative specification of the control variables appear to be equally acceptable. The effect of BART on environmental quality and expectations is likely to be best picked up by the log-linear model while any net positive effects due to the access improvement are best picked up by the additive one.

2. The Functional Forms:

Should BART have had a large effect on property prices, then a straight-forward additive specification of equation 1 could be used to detect the impact, if not accurately measure it. A large impact is not expected and several functional forms of the general model will be used to detect one. The first equation uses the raw data without transformations:

Model 1

$$P_i = c + \beta d_i + \sum_{j=1}^{L} \alpha_j Q_{ji} + E_i \qquad i = 1, \ldots, n$$

and:

$$\frac{\partial P_i}{\partial d} = \beta$$

The appeal of this equation lies in its simplicity. The equation does not account for the fact that the slope of the price gradient may change with distance. The model has no assymptotic properties and the

parameter is affected by the choice of the boundaries of the geographical area from which data was obtained. The distance coefficient describes BART's net impact on the Rockridge price-gradient and the model does not account for the fact that this premium may correlate with the prices paid for the other housing attributes.

Model 1'

$$P_i = c + \beta_1 d_i + \beta_2 d_i^2 + \sum_{j=1}^{L} \alpha_j Q_{ji} + E_i \qquad i = 1, \ldots, n$$

and:

$$\frac{\partial P_i}{\partial d} = \beta_1 + 2\beta_2 d$$

Since the impact is expected to attenuate with distance, the coefficient for the distance squared variable is expected to have the opposite sign to that for the linear variable. The introduction of the second distance variable clearly reduces the power of the test. The variance of the estimates is increased and the degrees of freedom are reduced.

Model 2

$$P_i = c + \beta d_i^{-1} + \sum_{j=1}^{L} \alpha_j Q_{ji} + E_i \qquad i = 1, \ldots, n$$

and:

$$\frac{\partial P_i}{\partial d} = -\beta d^{-2}$$

$$\lim_{d \to \infty} \hat{P}_i \to \sum_{j=1}^{L} \alpha_j \hat{Q}_{ji} + E_i$$

The reciprocal transformation of the distance variable yields a model with attractive assymptotic properties and specifies an impact which attenuates rapidly with distance. This is a specific form of equation 4 in which β_2 is assumed to equal -1. Since only one variable is used to pick

up the slope and rate of change in slope, the power of the hypothesis test is not reduced as it was with Model 1'.

Model 3

$$\log P_i = c + \beta \log d_i + \sum_{j=1}^{L} \alpha_j \log Q_{ji} + E_i \qquad i = 1, \ldots, n$$

or:

$$P_i = c d_i^{\beta} \prod_{j=1}^{L} Q_{ji}^{\alpha j} e^{E_i} \qquad i = 1, \ldots, n$$

and:

$$\left.\frac{\partial P}{\partial d}\right|_{d,\underline{Q}} = \frac{\beta}{d} c d^{\beta} \prod_{j=1}^{L} Q_j^{\alpha j} = \frac{\beta}{d} P$$

This multiplicative form specifies a price impact which is proportional to the amount paid for the house and one which may attenuate with distance. The model specifies a premium whose size changes inversely with distance and varies proportionally with the price paid for the house. It ignores the belief stated earlier that the true relationship between the access premium and the amount paid for the other housing attributes is an additive one. If the net effect of BART is negative, this model is likely to offer the most powerful test of the null hypothesis.

The final functional form to be tested involves the use of prior information. Equation 4 lends itself to the following non-linear expression whose parameters cannot be estimated by means of ordinary least squares:

Model 4'

$$P_i = \beta_1 d_i^{\beta_2} \prod_{j=1}^{N} Q1_{ji}^{\alpha 1j} e^{E1i} + c \prod_{j=1}^{L} Q2_{ji}^{\alpha 2j} e^{E2i} \qquad i = 1, \ldots, n$$

where: the first expression on the right hand side of the equation describes the BART premium as a function of distance and the housing attributes Q1.

The second expression describes the prices people have paid for the other housing attributes Q2 and should control for the non-BART factors.

If houses are fairly appraised and if the appraisors have not, as they say they have not, adjusted the roll values on account of BART, then Model 4' can be adjusted and rewritten as follows:

Model 4

$$P_i \div Rv_i = c\, d_i^{\beta} \prod_{j=1}^{L} Q1_{ji}^{\alpha 1j}\, e^{E1_i} \qquad i = 1, \ldots, n$$

where:

P_i is the price of house i.

Rv_i is the appraisor's estimated roll value of the house. It represents the appraisor's belief as to the market value of the house.

c is the coefficient for the constant term. It describes the average ratio of sales price to roll value and accounts for any deliverate discrepancy between these two variables.

$Q1_{ji}$ are the characteristics across which we expect to observe different price changes that are attributable to the presence of the BART station.

E_i is the error term.

Since the Assessor is fair, the discrepancy between sales price and roll value is proportional to the value of the house and the constant form accounts for it. Since the appraiser believes that the Rockridge BART station has not affected the sales price of houses, the roll value will not reflect any BART induced price changes which may actually have occurred. If BART has not had an impact, then, with the exception of the constant term, all parameters on the right hand side of the equation are equal to zero. If BART affected prices, then the coefficients for the variables will describe the price impact across distance and the other housing attributes.

3. The Variables:

The building's environment, lot characteristics, structural and architectural characteristics are expected to affect its sales price. These attributes may vary with distance to the BART station and variables describing them should be considered for inclusion into the regression equation. The required control variables and the available data are described in the following list:

1. ENVIRONS:

<u>Environmental impacts of BART and the Grove-Shafter Freeway</u>: Data is available on a variable which describes whether or not the assessor believes each house to be adversely affected by its proximity to the freeway. It is not possible to distinguish between the environmental effects of the freeway from those of the BART line. Both systems simultaneously affect the quality of the Rockridge physical environment and the "freeway" variable should control for this impact.

<u>Street quality and traffic</u>: Variables in the assessor's files tell whether the house is situated on a through street, boulevard or cul-de-sac. The extent of traffic on the street (heavy, medium, light) is given.

Prevalence of special nuisances: Variables describe the assessor's judgment as to whether or not a house is so close to shops, parks, schools that the proximity constitutes a "nuisance." One variable lists the number of prevalent nuisances which are expected to affect the market value of the house.

Neighborhood aesthetic qualities: Categorical variables identifying three areas of Rockridge have been entered into the data base. The slope of the street is given and this variable can be used to pick out the hill-side houses. While it is commonly said that Rockridge is a diversified community containing a wide variety of houses, it is possible to identify sub-neighborhoods across which neighborhood quality is relatively uniform. Three categorical variables were entered into the data base to identify the area east of College Avenue, the area west of the shopping strip but south of Claremont Avenue and the area in the northwest sector.

Racial characteristics of the neighborhood: Data on the racial characteristics of the environs is not available and the sub-neighborhood variables do not adequately control for this factor. The omission of this variable could be serious were it not for the observation that ethnic characteristics correlate with some of the building and neighborhood characteristics variable. Therefore, the effect of changes across Rockridge in the racial characteristics of its population may in part be controlled for by the building and neighborhood variables. The effect of several recent multi-family public housing projects remains uncontrolled for. The number of such projects is small and they are scattered across one of the sub-neighborhoods. Should their omission bias the estimate of the BART impact parameters, the bias is expected to be very small.

Zoning of lots: Data is available on the current zoning of each lot. Since Rockridge has recently been downzoned, data is unavailable on the zoning which prevailed at the time the house was last sold. Since zoning was quite uniform across the residential areas identified by the categorical variables, the omission of conrols for differences in zoning ordinances causes us no problems.

2. LOT CHARACTERISTICS:

Lot size: Data on the actual area of each lot is available as well as on the usable lot area.

Lot slope: After accounting for the positive effect of hillside locations, sloping lots are expected to sell for less than level lots. A variable describing the slope of the lot is available.

3. BUILDING CHARACTERISTICS:

Building size and dimensions: The variable listing the square foot area of the house when used in conjunction with one listing the number of rooms in the house will partially control for differences

across space in both the size of the houses and their quality. A variable describing the average size of rooms was constructed to control for differences in the "spaciousness" of houses.

Structure type and quality: Data is available on the appraiser's assessment of the "quality class" of each building.

Condition of building: Houses with recent improvements or with deferred maintenance are identified. Unfortunately, the variables describe the "current" condition of the buildings and do not necessarily indicate the condition they were in when last sold. People buying houses will often make improvements. The variable identifying recent improvements may in fact identify houses which were in poor condition at the time they were sold. Deferred maintenance may have occurred after the purchase of a house by a speculator. The coefficients for these variables may have the opposite sign from that which is expected: recently improved houses may have been in poor condition at the time of sale and had a depressed sales price. The older the sale the greater is the effect of the discrepancy.

Architectural quality: The exterior finishes, the roof slope, the prevalence of a "rustic" character of each house are described in the data base along with the assessor's judgment as to whether or not their plans are functional. The "functional plan" and the "exterior finishes" variables can be used as proxies for architectural quality. The average room size variable, listed earlier, and the presence of central heating and the number of fireplaces will in part be controlling for the differences in the quality of Rockridge houses.

Features: The data on heating systems, garage type, number of fireplaces, number of bathrooms, finish of basements, and the number of items such as range, dishwasher, refrigerator will be used.

4. DISTANCE TO THE BART STATION:

Walking distance to the BART station: The variable used measures the distance from the station to the center of each block. The variable has a stochastic component with an expected mean equal to zero and a standard error whose magnitude is estimable. The error will not affect the expected value of the estimated distance parameter. The stochastic component will, however, increase the variance of the estimate and therefore reduce the power of the statistical tests.[5]

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[5]Consider the true model to be (1) and the model used to be (2).

(1) $P_i = \beta d_i^* + \alpha Q_i + E_i \qquad i = 1, \ldots, n$

(2) $P_i = \beta(d_i + U_i) + \alpha Q_i + E_i$

$= \beta d_i + \alpha Q_i + \beta U_i + E_i$

Cont.

The Assessor's data base appears to be adequate for our purposes. No serious specification errors are expected as a result of unavailable data. The final selection of variables will be based on an examination of the data and the final specified list will be presented along with the findings. Variables which exhibit little if any variation will not be included in the equations. Control variables which are highly correlated with others that have a greater effect on price will automatically be excluded in the process of estimating the parameters.

The standard deviation squared of the distance variable d_i (measured in units of 50 feet) is approximately 75. The typical block in Rockridge is about 200 feet by 500 feet and the typical lot is 50 feet by 100 feet, making the absolute value of U to lie between 125 feet and 325 feet. Measured in units of d the front door of the house i can be in equal probability at distance $d_i \pm 2.5$; 3.5; 4.5; 5.5; 6.5. The expected variance of U is approximately 25, and therefore the standard deviation squared of d_i^* is approximately 100. We know also that the standard deviation of P_i is approximately 8,000. Expecting the right hand variables to account for approximately 90% of the variance in price, the expected variance of E is approximately 640,000. Assume that the true value of β is $-10, prices drop $10 for each 50 feet distance from BART, and assume that the correlation between d and Q is .5 and that observations on approximately 600 houses are on file. The expected variance of b1 using model (1) and of b2 using model (2) are:

$$(1) \quad V(b1) = \sigma_E^2/nS_{d^*}^2(1 - \rho\, d,Q) = 640{,}000/(600 \times 100 \times .5) = 21.3$$

$$(2) \quad V(b2) = (\beta^2\, \sigma_u^2 + \sigma_E^2)/nS_d^2\,(1 - \rho\, d,Q) = (100 \times 25 + 640{,}000)/(600 \times 75 \times .5) = 29.6$$

The standard deviation of b1 is 4.62 and of b2 is 5.44. If we are willing to reject the null hypothesis when the estimated absolute value of b is greater than its standard deviation, then the error introduced by measuring to block centers is expected not to matter provided that the BART impact is greater than $5.35 per 50 feet or less than $4.62 per 50 feet: if it is less, neither model will reject the null hypothesis: if it is greater, then both will reject it.

4. The Approaches

A cross-sectional, a before-after, and a combined cross-sectional-longitudinal approach can be used to identify the BART impact and it is the aim of this section to evaluate these alternatives. For convenience, the discussion will consider a model containing only three variables whose means have been set equal to zero, i.e.,

$$5. \quad P_i = \beta d_i + \alpha Q_i + E_i \qquad\qquad i = 1, \ldots, n$$

The hypothetical variable Q accounts for all non-access related housing attributes that affect the price of houses and are correlated with distance. The conclusions drawn by the use of this hypothetical model can be generalized and applied to the case where all the control variables are used.

The Cross-Sectional Approach

Since specification errors due to omitted variables are not expected to occur, the cross-sectional approach will yield reliable estimates of the price gradient if:

1. The non-BART access attributes across the study area are uniform, and if
2. the number of observations is large and extreme-multicollinearity between the distance and other variables does not prevail.

If BART planners consciously placed the system in what they expected to be the trough of the non-BART (or, other-than-BART) access surface, then the cross-sectional approach will lead to an underestimate of the true BART impact. The impact is identifiable with the cross-sectional post-BART approach if case 1, not case 2, in Figure 4 holds true.

Figure 4

Case 1

Case 2

We have no reason to believe that the non-BART access surface across Rockridge is represented by case 2. There are no strong local influences except for BART on the area's access surface. There may, however, have been changes in slope, the non-BART access surface concurring with those potentially induced by the BART system. In the early sixties, Berkeley was able to absorb the demand for housing close to the University of California campus. In the late sixties pressure on the Berkeley and U.C. Campus related housing market increased.

Figure 5

The Expected BART Impact with and without Increase in Demand for Access to Berkeley

Legend:

"a" change in the bid-price gradient by Berkeley oriented people.
"b" change in the bid-price gradient by others.

The spillover into parts of Rockridge of Berkeley-oriented people increased in the seventies. The non-BART price gradient could have shifted upwards in the direction of Berkeley. If the Berkeley-oriented market was distinct from the Oakland and San Francisco CBD-oriented one, an upward shift in the Berkeley direction would have reduced the magnitude of the BART impact but would maintain uniform the non-BART gradient.[6] The cross-sectional approach can legitimately be used but its power is reduced. Possible shifts in the spatial orientation of the buyers may have increased the slope of the price gradient in the Berkeley direction and reduced the measurable impact that the BART station may have had. The number of observations in the post-BART (post 1973) universe may not be sufficiently large to enable us to detect a small impact. A reduction in the number of control variables may ease the situation at the expense of possibly yielding a misleading result. A comparison of the mean squared error, MSE_1, using the full specification of equation 5 with that, MSE_2, resulting by omitting variable Q can yield an estimate of the minimum number of observations, $\overline{N}$, needed in order to use the fully specified equation 5.

6.1 $MSE_1 = V(b_1) = \sigma_E{}^2/nS_d^2\ (1 - \rho dQ^2)$

6.2 $MSE_2 = V(b_2) + Biase^2 = \sigma_E{}^2/nS_d^2 + \alpha^2\rho dQ^2 S_Q{}^2/S_d^2$

6.3 $\overline{N} = \sigma_E{}^2/\alpha^2\ S_Q{}^2\ (1 - \rho dQ^2)$

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[6] If the Berkeley orientation was large enough and if Berkeley oriented people didn't particularly care for BART, the shift in the Berkeley gradient could have precluded the station from having any impact at all on the price of Rockridge housing.

where:

σ_E^2 is the variance of the error term in equation 5.

S_d^2 is the standard deviation of the distance variable squared.

S_Q^2 is the standard deviation of the quality variable squared.

ρdQ is the correlation between the distance and quality variable.

$\overline{N}$ is the minimum number of observations needed in order for the mean squared error of the fully specified model to be less than that using the model with the omitted variables.

We conclude that variables with little price effect, or which are not highly correlated with sales price or with the distance variable can be omitted. Variables whose standard deviation is small relative to that of the distance variable should also be excluded from the equation. Variables with strong price effects, highly correlated with distance and with large standard deviations must be included. The final determination of control variables will be made after the variance-covariance matrix has been examined.

The Before-After Approach:

If the cross-sectional approach fails to reveal the BART impact, and if near-extreme multicollinearity between the distance and control variable is suspected, the almost-before-after approach will be considered. This method attributes to BART the difference in the price gradients measured with pre- and post-BART data. The before-after method may offer the advantage of permitting fewer control variables. Whereas relevant variables in the cross-sectional models had an effect on price, correlated with the distance variable and had a standard deviation which was at least not small relative to that of the distance variable; the relevant control variables using the before-after approach are those:

1. Which affect sales price; and

2. which do not have a small standard deviation relative to that of the distance variable; and
3. which are correlated with distance; and
4. whose true implicit prices have changed over time; and/or
5. whose correlation with the distance variable have changed over time; and/or
6. whose standard deviations, relative to that of the distance variable, have changed noticeably over time.

Variables in the cross-sectional list may be dropped whether we believe that the prices associated with them, their correlation with the distance variable, and their standard deviation relative to that of the distance variable are the same across the two time periods.

Consider the following relationships to be true. The first equation presents the true "before" model, the second the true "after" equation. The third describes our belief that the true "before" gradient surrounding the station was flat. The next two equations describe the relationship between distance from BART and the characteristics of houses. The last describes the true "after" price of the qualitive variable as the "before" price plus a constant increment:

7.1 $P_{1i} = \beta_1 d_{1i} + \alpha_1 Q_{1i} + E_{1i}$ $\qquad i = 1, \ldots, n$

7.2 $P_{2i} = \beta_2 d_{2j} + \alpha_2 Q_{2j} + E_{2j}$ $\qquad j = 1, \ldots, n$

7.3 $\beta_1 = 0$

7.4 $Q_{1i} = C_1 d_i + V_{ij}$ $\qquad i = 1, \ldots, n$

7.5 $Q_{2j} = C_2 d_j + V_{2j}$ $\qquad j = 1, \ldots, n$

7.6 $\alpha_1 = \alpha_2 - C_3$

The expected bias using the before-after method of measuring the BART impact can be shown to be:

$$E\ (b_2 - b_1 - \beta_2) = (\alpha_2\ C_2) - (\alpha_1 C_1) = \alpha_2 (C_2 - C_1) - C_3\ C_1$$

$$= \alpha_2 (\rho Q_2 d_2 \frac{SQ_2}{Sd_2} - \rho Q_1 d_1 \frac{SQ_1}{Sd_1}) - C_3\ \rho Q_1 d_1 \frac{SQ_1}{Sd_1}$$

If critera 5 and 6 do not apply to variable Q (they will apply if BART affected the type of houses sold at different distances from its station) and if we have prior knowledge of the way prices have changed for the qualitative attributes, the bias is computable and the before-after estimate of the BART impact can be adjusted accordingly. Whether or not criteria 5 and 6 apply to a variable can be determined by examining the data.

The expected value of the estimated distance parameter is the bias term in the post-BART estimate using the condensed model. Since reliable estimates of the BART impact are sought, the before-after approach will be considered only of the estimated pre-BART parameter is statistically significant. If variable Q is not a relevant control variable according to the six criteria listed earlier, the mean squared error of the before-after estimate of the BART impact is simply the sum of the variances of the estimated parameters. Table 2 compares the fully specified, the partially specified cross-sectional and the before-after approaches. Assumed is that attribute Q covaries with the distance variable but its distribution and associated price have not changed with time. The variance of the error term and the number of observations is assumed to be the same in the pre- and post-BART samples.

Table 1

Comparison of Mean Squared Errors of Three Variable Models Using the Complete Cross-Sectional (MSE_1); Partial Cross-Sectional (MSE_2); and Before-After (MSE_3) Approaches.

$$MSE_1 = \frac{\sigma_E^2}{nS_n^2 (1 - \rho_{Qd}^2)}$$

$$MSE_2 = \frac{\sigma_E^2}{nS_d^2} + \alpha^2 \rho_{Qd}^2 \frac{S_Q^2}{S_d^2}$$

$$MSE_3 = \frac{2\sigma_E^2}{nS_d^2}$$

$$MSE_2 < MSE_1 \text{ when } (1 - \rho_{Qd}^2)\, \alpha^2 S_Q^2 < \frac{\sigma_E^2}{n}$$

$$MSE_3 < MSE_2 \text{ when } \rho_{Qd}^2\, \alpha^2 S_Q^2 < \frac{\sigma_E^2}{n}$$

$$MSE_3 < MSE_1 \text{ when } \rho_{Qd}^2 > \frac{1}{2}$$

The 600 observations taken on the most recent sale since March 1968 are split into three groups of about 200 each. The "before" observations range in age between March 1968 and April 1971 and the "after" observations between January 1973 and January 1975. The average age of houses in the two samples are January 1970 and January 1974. If the price gradient is expected to emerge more or less linearly in time since the announcement of the BART system and the Rockridge station location, the before-after approach as used here measures the impact as it has occurred between

these two periods. Since some impact may be traced in the "before" period, the expected value of $b_2 - b_1$ is smaller than would be the case should true pre-BART data be used. The before-after approach to the County Assessor's data offers the advantage of requiring fewer control variables and the disadvantage of seeking to identify and measure a smaller impact.

The best determination of the relevant control variables to be included in the "before-after" approach would be based on an examination of separate "before" and "after" regressions. Variables with large differences in their before- and after-estimated parameters should be considered for inclusion in the final runs. The number of regressions needed would overtax the Alameda County Assessor's hospitality and prior knowledge of price changes will be used to specify the control variables. Recent trends in the price of existing houses, in Oakland, have shown that the prices of large and spacious houses have increased proportionally more than have the prices of small houses. The price of hillside houses has also increased relative to the price of other houses. The control variables to be included when using the "before-after" approach should describe the square foot area of the building, the average size of rooms, the lot's slope and size.

The before and after approach has been viewed as one utilizing independent pre- and post-BART observations. A version of this approach considers the grouping and pairing of observations. Since this adaptation of the before-after approach has been described in detail by David Dornbush (1974), it will be reviewed only briefly.

The n observations in equations 6.1 and 6.2 can be classified according to K groups of T_K observations in each group.

$$7.1 \quad P_{1K} = \beta_1 \bar{d}_{1K} + \alpha_1 \bar{Q}_{1K} + \bar{E}_{2K} \qquad k = 1, \ldots, K$$

$$7.2 \quad P_{2K} = \beta_2 \bar{d}_{2K} + \alpha_2 \bar{Q}_{2K} + \bar{E}_{2K} \qquad k = 1, \ldots, K$$

where:

$$\bar{P}_K = \frac{1}{T_K} \sum_{t=1}^{T_K} P_{tk} \quad \text{etc.}$$

If separate estimates of β_1 and β_2 are made for each equation, the grouping produces less efficient estimates of the parameters than would be the case if individual observations are used. The loss of efficiency is proportional to the loss of the variance of the distance variable as a result of aggregating the observations. If, however, the groups have been selected in such a manner that the average value of the right hand variables are the same in the pre- and post-BART group, then improved estimates can be obtained by pairing the data and estimating β_1 with OLS using the model:

$$7.3 \quad \bar{P}_{2k} - \bar{P}_{1k} = (\beta_2 - \beta_1)\bar{d}_k + (\alpha_2 - \alpha_1)\bar{Q}_k + \bar{E}_{2k} - \bar{E}_{1k} \qquad k = 1, \ldots, K$$

Because the two error terms account for the effect of the omitted variables which are assumed to have the same values in the before and after groups, the error terms are positively correlated. The estimate $(b_2 - b_1)$ is better than one obtained by estimating the separate parameters with the same number of observations.

Therefore, the fewer the number of observations needed in each group to achieve comparability in the before- and after- housing characteristics, the more reliable the estimates. The closer the spatial aggregation describes concentric circles around the BART station, the less the reduction in the variance of d and the more precise the estimate.

The ideal case would present itself if each house in the before sample were matched with a similar house in the after sample. Practical considerations precluded the use of this approach.

The Cross-Sectional-Longitudinal Approach

This method introduces the time dimension, permits the use of all the observations available and increases the difficulty of model specification and of interpretation. Ignoring time and using the cross-sectional approach on all the data would yield an estimate of the distance parameter which accounts for BART's effect on the true price gradient as well as its effect on the change in the type of houses bought across both time and distance adjusted for changes across time in the hedonic price index. If the true model is represented by equation 8.1 and the cross-sectional model 8.2 was estimated, the expression 8.3 describes the estimated price gradient when the time variable takes on the value of zero (as before, all variables have standardized means).

$$8.1 \quad P_i = \beta_0 d_i + \alpha_0 Q_i + \beta_1 t_i d_i + \alpha_1 t_i Q_i + E_{1i} \qquad i = 1, \ldots, n$$

where:

β_0 is the true current price gradient at time $t = 0$.

α_0 is the true current implicit price for attribute Q at time $t = 0$.

β_1 is the change in the price-gradient per unit of time going back and for convenience this change is assumed to be constant over time.

α_1 is the change in the price of attribute Q over time and again the change in price is assumed to be a linear function in time.

$$8.2 \quad P_i = \beta d_i + \alpha Q_i + E_{2i} \qquad i = 1, \ldots, n$$

$$8.3 \quad E(b) = \beta_0 + \beta_1 C_1 + \alpha_1 C_2$$

where:

C_1 and C_2 are the partial correlation coefficients found by regressing the distance and qualitative variables against the interaction terms, i.e.,

$$d_i t_i = c_1 d_i + c_1' Q_i + \gamma_{1i} \qquad i = 1, \ldots, n$$

$$d_i Q_i = c_2' d_i + C_2 Q_i + \gamma_{2i} \qquad i = 1, \ldots, n$$

Equation 8.3 describes the expected value of the cross-sectional estimate as the sum of the true gradient as it prevails through the time period t = 0 and two terms which can be rewritten as:

$$8.4 \quad \beta_1 C_1 = \beta_1 \cdot \frac{\sum Q_i^2 \sum d_i^2 t_i - \sum d_i Q_i \sum d_i t_i Q_i}{\Delta}$$

$$8.5 \quad \alpha_1 C_2 = \alpha_1 \cdot \frac{\sum d_i^2 \sum Q_i^2 t_i - \sum d_i Q_i \sum d_i t_i Q_i}{}$$

where: $\Delta = \sum d_i^2 \sum Q_i^2 - (\sum d_i Q_i)^2$

The interpretation problem disappears whenever observations were made during one time period, i.e., when the true cross-sectional model is used on observations taken at some point in time. If the rate of change in prices have been the same (i.e., $\alpha_1 = -\beta_1$) and if the correlation between the distance and the qualitative variables have not changed over time, then the interpretation problem again disappears: The price gradient estimated by using equation 8.2 is the one prevailing at time t = 0. Without these assumptions the interpretation of the estimated cross-sectional parameters must rest on beliefs regarding the rate

of change in prices across time and changes in the types of properties sold across both space and time.

The explicit introduction of time series attempts to ease the interpretation of the estimated parameters and to yield information on the rate of change in prices. This, however, is done at the cost of seriously complicating the specification problem. If equation 8.1 represents the final form of the desired model, then what is required is a new general model which explains the evolution of the BART premium across time, an examination of the change in the prices of other housing attributes and a respecification of the variable transformations. The price for large, spacious, hillside or proximate to BART houses has changed over time but we don't know exactly how. These are the same variables used in the before-after approach. Not having a dynamic model of BART impacts leaves us with the option of identifying the interaction terms by examining the data. Initially a set of categorical variables will be introduced to search for time-attribute-price relationships. To be consistent with the earlier approaches, three dummy variables identifying the "before," the intermediate and the "after" periods will be constructed. The interaction variable will be constructed by simply multiplying these variables with those describing the attributes whose prices are expected to have changed.

III

FINDINGS

The first part of this chapter describes the sold properties and compares them to the other Rockridge houses. The regression results using the four models described in the last chapter are presented next and the conclusions follow.

1. Description of Sold Houses:

Of the 2263 houses in the study area, 886, 40%, are located in the visually more attractive area just east of College Avenue. Of the 602 latest sales transactions since March of 1967, 40% occurred in this area, indicating that the homeowners' propensity to sell did not differ across subneighborhoods. The average distance to the BART station is 1285 feet for all houses compared to 1275 for the sold ones. The variance of the distance variable for all houses is 21350 compared to 20925 for those that were sold.

Table 2 presents the spatial distribution of sales with respect to distance to the BART station of house sample. A Kendall's Rank-Order Correlation test was used to search for a trend and none was found; sales activity has not increased in the area adjacent to the station relative to more distant sections of Rockridge.

Table 3 presents statistics on depreciation rates. Houses east of College Avenue have depreciated proportionally less than those on the other side but within each area the depreciation of the sold houses is comparable to that experienced by other houses. Most of the houses considered by the

TABLE 2

Distribution of Sales with Respect to Distance
From the BART Station

Distance* (50 ft. units)	Number of Houses	Number of Sales	Proportion Sold	Rank of Proportion
6-9	118	30	25.42	6
10-14	159	38	23.90	5
15-16	177	47	26.55	8
17-20	184	60	32.61	14
21-22	176	54	30.68	13
23-26	173	47	27.01	9
27-28	104	29	27.88	10
29-29	175	36	20.57	1
30-30	167	47	28.14	11
31-32	156	26	22.41	4
33-34	154	51	33.12	15
35-36	155	40	25.81	7
37-37	133	29	21.80	3
38-39	145	31	21.38	2
40-42	127	37	29.13	12
Total/Average	2263	602	26.60	

Kendall's Correlation Statistic	-7
Coefficient of Rank Correlation	-.0667
Significance	.78

*The depth of the consecutive rings was adjusted in the attempt to equalize the number of houses in each group. A non-parametric correlation statistic was used because the depth of the sectors varies.

TABLE 3

Depreciation Rates

	East of College Ave.		West of College Ave.	
	All Houses	Sold Houses	All Houses	Sold Houses
Assessed land value	$20,605	$20,652	$15,351	$15,440
Replacement cost new	33,588	33,508	25,016	25,348
Depreciation amount	18,793	18,685	15,378	15,905
Depreciation % of RCN	56%	56%	61%	63%
No. with deferred maintenance	2	0	33	2
% with deferred maintenance	.23%	0	2.4%	.55%

appraisor to be in need of major repairs are to the west of College Avenue and very few of them have been sold since 1967. Should speculators have under-maintained their properties while planning to convert to a higher intense use, then they have entered the market before 1967 and their effect on sales prices will not be picked up in this study. The similarity between the sold and the other houses suggests that BART has not caused the housing stock to deteriorate.

Table 4 lists the means and standard deviations of the variables. The first column presents statistics on all houses in the study area, the second and third columns describe the houses sold before January 1971, and those sold since January 1973. A comparison of the columns reveals that the sold groups are representative of Rockridge houses with one

TABLE 4

Means and Standard Deviations of Variables
Used in Regression Analysis

No.	Variable Name	All Single-Family Houses in the Study Area		Properties Last Sold Before March 1971		Properties Last Sold Since January 1973	
		Mean	S.D.	Mean	S.D.	Mean	S.D.
133	PRICE			23,960.000	7339.800	30,464.000	8830.000
24	d (50' units)	25.69	8.54	25.500	8.810	26.010	8.383
91	FREEWAY BAD	.04	.17	.033	.179	.022	.141
4	RCN GAR/1000	1.10	.68	1.140	.728	1.032	.632
6	TOTAL FT BLDG	1568.72	513.00	1561.300	509.800	1521.200	449.700
16	USABLE AREA LOT	4422.18	1781.33	4282.200	1343.400	4302.300	2235.100
17	CLASS/62	.97	.09	.975	.093	.969	.075
20	AGE BLDG	58.82	9.15	58.120	9.930	59.950	7.370
21	TOTAL RMS	6.13	1.24	6.044	1.174	5.978	1.092
26	NO. BATHS	1.34	.51	1.354	.525	1.264	.445
30	GOOD COND	.06	.24	.050	.217	.093	.292
31	FAIR COND	.06	.22	.030	.171	.071	.258
50	CENTL HEAT	.47	.50	.467	.500	.418	.495
52	NO. FIREPLACES	.97	.69	.940	.423	.995	.551
54	EXTRA EQUIP	.18	.80	.176	.587	.104	.452
55	STUCCO	.54	.50	.505	.501	.478	.501
56	SHINGLE	.22	.41	.225	.419	.286	.453
57	RUSTIC	.17	.37	.044	.206	.165	.372
60	STEEP ROOF	.15	.36	.176	.382	.137	.345
69	DEAD END	.03	.14	.049	.217	.005	.074
72	STREET SLOPE	.12	.53	.093	.310	.115	.337
74	THRU STREET	.05	.22	.044	.205	.071	.258
79	STREET PVG	.17	.37	.170	.377	.192	.395
84	MED. TRAFFIC	.05	.22	.049	.217	.055	.229
85	HEAVY TRAFFIC	.06	.22	.044	.206	.066	.249
106	NUISANCE	.10	.60	.115	.411	.077	.323
112	LEVEL	.37	.72	.341	.685	.434	.761
113	SLOPE	.28	.55	.264	.533	.335	.597
125	IMPS*NEW	.04	.20	.049	.217		
127	BAD*LOCS	.19	.54	.192	.567	.181	.541
132	AGE SALE			68.290	10.040	14.630	5.689
161	N1 E OF COLLEGE	.40	.49	.357	.480	.423	.495
162	N2 NW OF STN			.319	.467	.253	.458
165	N3 SW OF STN			.324	.469	.324	.469

explainable exception: 9.3% of the most recently sold houses while 5.73% of all houses have been deemed by the appraisor to be in "good condition," i.e., in better than the normal conditon of houses with similar age and class of construction. Correspondingly, 5.79% of all houses in Rockridge are below the normal condition while 3.99% of sold houses are in this category. People after buying their home tend to fix it up and some sellers repair their property before putting it on the market. This finding, the Alameda County Appraisor's Office assures me, is not unique to Rockridge. BART does not appear to have changed the demand for one type of house relative to that for another type.

Table 5 describes the relationships between distance, price and the candidate control variables. Correlation coefficients smaller than .10 in magnitude are not printed. Larger buildings on large lots tend to be located further from the station and size is highly correlated to the sales price. The houses in above average condition are also located further away but the correlation coefficient between this and the price variable is less than .10. Houses in "fair condition" cost less but are distributed more or less evenly across the west side of Rockridge. The age of sale is not correlated with distance and we can therefore conclude that there has been no major shift in the location of sales since 1967. Houses west of College are approximately 45% more expensive than houses on the other side of the street. Nuisances, other than those caused by schools, heavy traffic or the freeway, and "Bad Locations" appear to be evenly distributed with respect to the station and houses on such lots sell for about the same amount as do the others. Stucco houses sold for more while the shingled houses went for less than average sales price. The "street paving" variable used by the assessor to identify

TABLE 5

Correlations Between Candidate Control Variables
and the Distance Price and Age Sale Variables
All Cases

		Distance	Price	Age Sale
155	PRICE	.1345	1.0000	-.3153
24	DISTANCE	1.0000	.1345	*
91	FREEWAY BAD	-.2349	*	*
4	RCN GAR/1000	.1055	.3984	.1917
6	TOTAL FT BLDG	*	.7181	.2158
16	USABLE LOT AREA	.1220	.5621	*
17	CLASS/10	*	.6859	*
20	AGE BLDG	-.2640	-.1678	*
21	TOTAL RMS	*	.5585	*
26	BATHS	*	.5780	*
30	GOOD CONDITION	.1299	*	*
31	FAIR CONDITION	*	-.1205	*
50	CENTL HEAT	.1098	.4307	*
52	FIREPLACES	*	.3342	*
54	EXTRA EQUIP	*	.1832	*
55	STUCCO	*	.2281	*
56	SHINGLE	*	-.1062	*
57	RUSTIC	*	-.1732	*
60	STEEP ROOF	*	*	*
69	DEAD END	.1187	*	*
72	STREET SLOPE	.2036	.2758	*
74	THRU STREET	*	*	*
79	STREET PVG	*	.1400	*
84	MED TRAFFIC	*	*	*
85	HEAVY TRAFFIC	.1100	*	*
106	NUISANCE	*	*	*
112	LEVEL	.3001	.4216	*
113	SLOPE	.2627	.4241	*
125	IMPS*NEW	.1979	*	*
127	BAD*LOCS	*	*	*
132	AGE SALE	*	-.3153	1.0000
165	GOOD FNC PLAN	*	.1810	*
161	N1 E OF COLLEGE	*	.4568	*
162	N2 NW OF STN	.3286	-.1633	*
163	N3 SW OF STN	-.3554	-.3243	*

* indicates a correlation coefficient of less than .10.

hillside properties is not correlated with distance but does pick out the more expensive houses. The most important control variables in the cross-sectional analysis using all observations describe interference from the freeway, assessed replacement cost of the garage, lot and building size, presence of central heating, street and lot slope and identify the three subsections of Rockridge.

Table 6 presents the correlation coefficients between these same variables across the pre-1971 and the post-1973 groupings. Most of the housing attributes that are related to the sales price are correlated less with the distance variable in the post-1973 group than they were in the earlier one. The effect of the control variables on the variance of the estimated distance parameter is expected to be small when using the recent sales. Since replacement cost of the garage, usable lot area, class of construction, number of baths, presence of central heating are highly correlated with sales price and the variables' correlation with distance has changed since 1971, the variables must be included as controls when attempting the almost-before-after approach. The primary control variables for the cross-sectional method using the recent observations are: age of building, age of sale, exterior finish, level and slope of lot and street, and the categorical variables identifying the subneighborhoods.

The correlations between the control variables and sales prices have also changed. The price difference across the neighborhoods appears to have increased. Although the difference is small, the correlation between usable lot area and price has decreased and that between floor area and price has gone up. The correlations with price of the variables describing the quality of the buildings have increased, while that between distance and price has dropped considerably. This suggests that the turnover rate

TABLE 6

Correlations Between Candidate Control Variables and the Distance and Price Variable and Age Sale in the Before and After Cases

		DISTANCE		PRICE		AGE SALE	
		Pre 1971	Post 1973	Pre 1971	Post 1973	Pre 1971	Post 1973
24	DISTANCE	1.0000	1.0000	.2503	*	-.1766	*
31	FREEWAY BAD	-.2802	-.2694	*	*	*	-.1752
4	RCN GAR/1000	.1827	*	.4264	.4321	-.1663	*
6	TOTAL FT BLDG	*	*	.6875	.7331	*	.1317
16	USABLE LOT AREA	.2203	*	.5917	.5482	*	.1518
17	CLASS/10	.1524	*	.7567	.7614	*	*
20	AGE BLDG	-.3189	-.3063	-.4977	-.4621	*	*
21	TOTAL RMS	*	*	.4681	.5459	*	.1561
26	NO. BATHS	.1200	*	.5641	.5974	*	.1368
30	GOOD CONDITION	*	.1578	*	*	*	*
31	FAIR CONDITION	*	*	*	-.1836	*	*
50	CENTRL HEAT	.1655	*	.4558	.4815	*	*
52	NO. FIREPLACES	*	.1145	.3093	.4052	*	.1368
54	EXTRA EQUIP	*	*	.2987	.2117	*	.1691
55	STUCCO	*	.1304	.1477	.3101	*	-.1260
56	SHINGLE	*	-.1348	-.1400	-.1095	*	*
57	RUSTIC	*	.1058	-.1445	-.2208	*	.1541
60	STEEP ROOF	-.1262	*	*	.2000	.1048	*
69	DEAD END	.2093	*	.3018	*	*	*
72	STREET SLOPE	.2338	.2559	.4052	.2746	*	*
74	THRU STREET	*	*	*	*	*	*
79	STREET PVG	.1159	*	.2667	*	*	-.2411
84	MED TRAFFIC	*	-.1158	*	*	*	*
85	HEAVY TRAFFIC	.1191	*	*	*	*	*
106	NUISANCE	*	*	*	-.1221	.1539	*
112	LEVEL	.2989	.3540	.5693	.3614	*	*
113	SLOPE	.2783	.2842	.5692	.3589	*	*
125	IMPS*NEW	.2728	*	.1690	*	*	*
127	BAD*LOCS	*	*	*	*	*	*
132	AGE SALE	-.1766	*	-.1747	-.1052	1.0000	1.0000
165	GOOD FNC PLAN	.1509	*	.1811	.2030	*	*
161	N1 E OF COLLEGE	*	*	.4296	.5201	*	*
162	N2 NW OF STN	.3562	.2142	-.1392	-.1984	-.1035	*
163	N3 SW OF STN	-.4399	-.2456	-.3012	-.3648	.1593	-.1358

of the better houses located near the station may have increased in the last five years. A comparison of the last two columns in Table 6 leads to the conclusion that there have been no systematic trends carrying across the last 8 years in the type of houses sold.

2. Regression Results:

The parameters for the four models described in the methods chapter were estimated using a stepwise procedure. The "distance" and the "freeway bad" variables were forced in and the control variables were allowed to enter provided they exceeded an F-level for inclusion of .10. The sequence in which the control variables entered could not be specified and in most runs more control variables were allowed in than were desired. This mars the aesthetics of the equations but does not change the conclusion. The variables are described in Appendix A.

Table 7 presents the results using model 1, and Table 8 lists the values the estimated distance coefficient took at each step. Although the null hypothesis cannot be rejected at the .10 level using a two-sided test, the signs of the coefficient suggest that prices near BART have dropped and that they have dropped more in the post-73 period than in the earlier one. In the first step, Table 9, distance is positively correlated with sales price and as control variables are entered the magnitude of relationship decreases but the sign doesn't reverse as would be the case should the access attributes of BART have determined its net impact. In the pre-71 group the estimated coefficient for the distance variable washes out after the inclusion of the first five control variables. In both regressions the entry of the distance squared variable improves the estimates, indicating that a curve fits the price gradient better than does a straight line.

TABLE 7

Regression Results: Model 1
Price Against Distance and Control Variables

		PRE-MARCH 1971		POST-JANUARY 1973	
		coef.	F-stat.	coef.	F-stat.
23	d	161.19	.749	348.43	2.086
151	d^2	-3.11	.661	-5.79	1.526
91	FREEWAY BAD	1392.47	.388	-2845.23	.903
4	RCN GAR/1000	787.82	2.379	709.13	1.715
6	TOTAL FT BLDG	6.14	18.030	9.16	56.090
16	USABLE LOT AREA	.72	6.530	.94	18.970
17	CLASS/10	22943.05	15.813	16930.42	5.824
20	AGE BLDG	-145.12	4.922	-108.72	3.263
21	TOTAL RMS	-284.93	.391	-277.01	.392
26	BATHS	-1531.44	2.611	ne	
30	GOOD CONDITION	1432.43	.910	ne	
31	FAIR CONDITION	ne		-1844.59	2.264
50	CENTL HEAT	1068.75	2.069	640.49	.685
52	FIREPLACES	ne		841.23	1.236
54	EXTRA EQUIP	377.46	.408	1968.35	8.533
55	STUCCO	-2114.97	2.758	-552.01	.511
56	SHINGLE	-1501.66	1.245	ne	
57	RUSTIC	-2278.38	1.245	-1706.30	3.636
69	DEAD END	-1599.39	.906	-7063.69	3.102
72	STREET SLOPE	ne		841.66	.516
74	THRU STREET	-2165.86	.906	11035.06	6.192
79	STREET PVG	796.85	.690	ne	
84	MED TRAFFIC	-956.85	.400	1189.10	.726
106	NUISANCE	ne		-3387.77	8.495
112	LEVEL	1441.56	4.485	ne	
113	SLOPE	ne		-1733.72	4.730
125	IMPS*NEW	-2633.16	1.652	ne	
127	BAD*LOCS	414.28	.192	4099.09	3.302
132	AGE SALE	-94.36	9.205	-325.90	32.796
161	N1 E OF COLLEGE	ne		3982.50	19.062
162	N2 NW OF STN	1881.10	4.060	ne	
165	GOOD FNC PLAN	ne		1626.09	4.204
	Constant	5053.53		7712.24	
R-squared		.7573		.8352	
F-statistic		19.4673		31.625	
Number of Cases		182		182	
Standard Error		3895		3861	

TABLE 8A

The Coefficients and F-Statistics for the Distance to BART Variables at Each Step During the Stepwise Entry of Control Variables

Model 1: Pre-March 1971

Step #	Variable #	Variable	Coefficient for the distance variable	F-Statistic for the distance variable
1	91	FREEWAY BAD	214	11.65
2	17	CLASS/10	120	8.25
3	6	TOTAL FT BLDG	128	11.61
4	162	LEVEL	99	6.81
5	132	AGE SALE	78	4.29
6	20	AGE BLDG	42	1.21
7	26	BATHS	43	1.34
8	162	N2 NW OF STN	8	.03
9	4	RCN GAR/1000	8	.03
10	125	IMP*NEW	10	.05
11	50	CENTL HEAT	6	.01
12	74	THRU STRT	11	.05
13	69	DEAD END	12	.07
14	79	STREET PVG	10	.04
15	55	STUCCO	9	.04
16	57	RUSTIC	11	.01
17	56	SHINGLE	15	.02
18	30	GOOD COND	8	.01
19	84	MEDIUM TRAFFIC	10	.01
20	151	d^2	137	.58
		Coefficient for d^2	-2.70	.53

TABLE 8B

The Coefficients and F-Statistics for the Distance to BART Variables at Each Step During the Stepwise Entry of Control Variables

Model 1: Post-January 1973

Step #	Variable #	Variable	Coefficient for the distance variable	F-Statistic for the distance variable
1	91	FREEWAY BAD	134	2.75
2	17	CLASS/10	54	.69
3	6	TOTAL FT BLDG	84	3.53
4	161	N1 E OF COLLEGE	70	2.61
5	132	AGE SALE	56	1.80
6	106	NUISANCE	69	2.92
7	54	EXTRA EQUIP	136	3.04
8	20	AGE BLDG	33	.64
9	74	THRU STREET	36	.79
10	113	SLOPE	50	1.78
11	165	GOOD FNC PLAN	52	1.67
12	57	RUSTIC	60	2.21
13	69	DEAD END	62	2.41
14	127	BAD*LOCS	56	1.94
15	31	FAIR COND	57	2.03
16	4	RCN GAR/1000	58	2.08
17	52	NO. FIREPLACES	55	1.90
18	151	d^2	329	1.94
		Coefficient for d^2	-5.42	1.39

After the first, the class of construction, variable is entered the difference between the two distance coefficients is not statistically significant and the almost-before-after approach does not permit us to reject the null hypothesis. As more variables are entered the power of this approach decreases.

Table 9 presents the estimated equation for model 2. If BART has caused the sales price of single family houses to increase, the coefficient for the reciprocal distance variable will be positive. A negative coefficient was estimated which is different from zero, at the .10 probability level using a two sided test. The null hypothesis is rejected in favor of the alternative stating that BART's net impact is negative. The Rockridge BART station appears to have caused a decline in the sales prices of houses.

Tables 10A and 10B show the value of the distance coefficient at each step during the entry of the control variables. The simple correlation between price and reciprocal distance is less than before. In the post-1973 regression the statistical significance develops only after control variables are entered. The variance of the estimate in both groups is less than it was when using the non-transformed distance variable. The curvature described by the reciprocal transformation appears to fit the price gradient better than did the straight line or the parabola. Table 11 describes the change in price and the price gradient with distance from the BART station. The slope has become steeper over time and the magnitude of the impact appears to have increased since 1971.

TABLE 9

Regression Results: Model 2
Price Against Reciprocal Distance and Control Variables

		Pre-March 1971		Post-January 1973	
		Coef.	F-Statistic	Coef.	F-Statistic
152	1/d	-14,403.00	1.232	-29,847.00	2.884
91	FREEWAY BAD	2071.00	1.265	-4,174.00	1.079
4	RCN GAR/1000	758.09	2.240	730.78	1.793
6	TOTAL FT BLDG	6.25	18.993	9.19	55.899
16	USABLE AREA LOT	.70	6.101	.91	5.789
17	CLASS/10	23,446.89	16.781	16,949.85	5.789
20	AGE BLDG	-131.39	4.109	-100.95	2.736
21	TOTAL ROOMS	-323.07	.516	-248.85	.316
26	BATHS	-1551.68	2.739	ne	
30	GOOD CONDITION	1327.45	.790	ne	
31	FAIR CONDITION	ne		-1822.25	2.197
50	CENTRL HEATING	1012.34	1.944	573.39	.543
52	FIREPLACES	ne		858.95	1.265
54	EXTRA EQUIP	406.83	.494	1900.89	7.885
55	STUCCO	-2091.68	2.748	-539.41	.487
56	SHINGLE	-1616.72	1.442	ne	
57	RUSTIC	-2326.46	2.825	-1745.22	3.631
60	STEEP ROOF	-276.05	.120	ne	
69	DEAD END	-1586.13	.900	-6845.14	2.901
72	STREET SLOPE	ne		812.39	.477
74	THRU STREET	-1449.50	.962	-9745.30	3.582
79	STREET PAVING	785.43	.680	512.44	.399
84	MEDIUM TRAFFIC	-1079.61	.518	-1194.85	.704
85	HEAVY TRAFFIC	ne		2609.99	.170
106	NUISANCE	ne		-3694.27	7.125
112	LEVEL	1363.81	4.250	ne	
113	SLOPE	ne		-1935.38	5.836
125	IMPS*NEW	-2723.92	1.863	ne	
127	BAD*LOCS			4747.57	2.804
132	AGE SALE	-89.41	8.628	-316.79	29.191
161	N1	ne		4082.77	19.025
162	N2	1600.49	3.549	ne	
165	GOOD FNC PLAN			1584.59	3.995
	Constant	6457.98		7016.50	
R-Squared		.7581		.8353	
F-Statistic		20.4981 182		30.2376 182	
Number of Cases		3876.		3872.	
Standard Error					

TABLE 10A

The Coefficients and F-Statistics for the Reciprocal Distance Variable at Each Step During the Entry of Conrol Variables

Model 2: Post-January 1973

Step #	Variable #	Variable Entered	Coefficient for 1/d	F-Statistic for 1/d
1	91	FREEWAY BAD	-28432	.617
2	17	CLASS/10	-20828	.780
3	6	TOTAL FT BLDG	-44644	4.560
4	161	NI E OF COLLEGE	-43323	4.741
5	132	AGE SALE	-36217	3.572
6	16	USABLE LOT AREA	-29576	2.595
7	106	NUISANCE	-32207	3.270
8	54	EXTRA EQUIP	-31578	3.325
9	20	AGE BLDG	-18338	1.073
10	74	THRU STREET	-20625	1.400
11	113	SLOPE	-25126	2.078
12	165	GOOD FNC PLAN	-25095	2.118
13	57	RUSTIC	-27807	2.615
14	69	DEAD END	-28916	2.861
15	127	BAD*LOCS	-27209	2.541
16	31	FAIR COND	-28475	2.800
17	4	RCN GAR/1000	-29569	3.030
18	52	FIREPLACES	-29031	2.925
19	72	STREET SLOPE	-27061	2.487
20	84	MEDIUM TRAFFIC	-27504	2.561
21	50	CENTL HEAT	-28560	2.730
22	55	STUCCO	-29131	2.822
23	79	STREET PAVING	-29979	2.959
24	21	TOTAL ROOMS	-30391	3.023
25	85	HEAVY TRAFFIC	-29847	2.884

TABLE 10B

The Coefficients and F-Statistics for the Reciprocal Distance Variable at Each Step During the Entry of Control Variables

Model 2: Pre-January 1971

Step #	Variable #	Variable Entered	Coefficient for 1/d	F-Statistic for 1/d
1	91	FREEWAY BAD	-47609	6.115
2	17	CLASS/10	-32625	6.652
3	6	TOTAL FT BLDG	-38810	11.825
4	112	LEVEL	-32123	8.256
5	132	AGE SALE	-26007	5.447
6	16	USABLE AREA LOT	-19989	3.285
7	20	AGE BLDG	-16917	2.343
8	26	BATHS	-17505	2.539
9	4	RCN GAR/1000	-17215	2.469
10	162	N3 NW OF STN	-10311	.728
11	57	RUSTIC	-11353	.881
12	74	THRU STREET	-12729	1.095
13	50	CENTL HEAT	-12696	1.089
14	125	IMPS*NEW	-11611	.904
15	55	STUCCO	-12475	1.040
16	56	SHINGLE	-14607	1.397
17	79	STREET PVG	-13977	1.274
18	69	DEAD END	-13849	1.248
19	54	EXTRA EQUIP	-15547	1.519
20	30	GOOD CONDITION	-13986	1.186
21	84	MEDIUM TRAFFIC	-14520	1.271
22	21	TOTAL ROOMS	-14744	1.306
23	60	STEEP ROOF	-14403	1.232

TABLE 11

Estimated Change in the Price Gradient and the Price of Single Family Houses, Using Model 2

Distance	Price Gradient*		Price Change	
	Pre-71	Post-73	Pre-71	Post-73
500 ft	$144	$298	-$1,440	-$2,985
1000	36	75	-720	-1,492
1500	16	33	-480	-995
2000	9	19	-360	-746
2500	6	12	-288	-597

*The price gradient describes the increase in sales price per 50 foot increase in distance from the BART station at varying distances from the station.

The first two models estimated the average price effect attributable to BART by using an additive specification. This functional form was thought to best suit the case in which the net impact was the result of the station's improving the access surface. Our findings indicate that prices have dropped, that the environmental factors have had the dominant effect. The discussion in the methods chapter pointed out that environmental consequences are likely to affect sales prices proportionately and therefore the multiplicative form is best suited to measure the magnitude of this impact. Table 11 presents the results using the log-linear model and confirms these beliefs. The price of houses increases with distance from the station after the negative environmental impact due to the freeway is controlled for and 31 other variables describing the buildings and their locations have been entered into the equation. Due to a programming error, the pre-1971 run aborted and instead the log-linear model using all observations is presented. In both cases the null hypothesis is rejected and the BART's dominant impact on sales prices appears to be brought about by the station's environmental consequences. The coefficient for the variable identifying houses whose value the appraisor feels has been detrimentally affected by the freeway is for the first time statistically different from zero and indicates that houses near the freeway sell for 13% less than do comparable houses located further away. Tables 13A and 13B show the value of the log distance coefficient at each step. The magnitude and the variance of the estimate is not affected very much by the control variables and remains statistically significant throughout the entire program.

The conclusion that BART has caused a price decrease would not change if only a subset of these control variables was used. Table 14 describes

TABLE 12

Regression Results: Model 3
Logrithmic (Base 10) Transformations of Continuous Variables

		ALL SALES		POST-JANUARY 1973	
		Coef.	F-statistic	Coef.	F-statistic
154	log d	.03937	4.2391	.05976	3.1851
91	FREEWAY BAD	-.03549	2.6464	-.10540	3.1484
155	log LOT AREA	.19476	55.6751	.12018	7.2766
156	log TOTL LVG AREA	.63954	14.9185	.49615	85.7167
157	log AVG RM AREA	-.21860	1.6645	ne	
158	log AGE SALE	-.15518	317.6260	-.14221	33.1733
159	log RCN GAR/10	.00646	6.8580	.00786	2.9188
21	TOTAL ROOMS	-.01013	0.7314	ne	
26	BATHS	.01051	1.7642	.00889	.4110
31	FAIR CONDITION	-.04087	8.6076	-.03110	2.5792
33	FUNC PLAN	.00296	.1869	.02042	3.0671
50	CENTL HEAT	.00992	2.4549	.00996	.7239
52	FIREPLACES	.01333	5.0893	.02815	9.1199
54	EXTRA EQUIP	.00743	2.8972	.02210	4.7404
55	STUCCO	ne		-.01184	.3710
56	SHINGLE	-.00887	1.7245	-.01624	.6999
57	RUSTIC	-.01559	4.3514	-.03897	3.4667
60	STEEP ROOF	ne		-.00485	.1283
69	DEAD END	-.02608	2.4291	-.08554	2.0806
72	STREET SLOPE	.00512	.2285	.00987	.2627
74	THRU STREET	-.08975	10.1518	-.12801	2.8782
79	STREET PVG	.00678	.7706	ne	
84	MEDIUM TRAFFIC	.00495	.1477	.01304	.3661
85	HEAVY TRAFFIC	ne		-.08816	.8903
98	VIEW	.01692	1.2635	ne	
106	NUISANCE	-.02090	4.3090	-.07321	12.6181
112	LEVEL	.01639	2.2976	.00783	.2269
113	SLOPE	-.02902	4.3090	-.02944	2.6686
116	STEEP*DOWN	-.01206	.2797	ne	
125	IMPS*NEW	.02455	1.4710	ne	
127	BAD*LOCS	.03019	5.0200	.08827	4.3701
138	EYR 50*59	.04577	2.1291	ne	
139	EYR 35*41	.05485	10.2531	ne	
161	N1 E COLLEGE	.04688	30.5164	.06140	17.5049
162	N2 NW STN	.00372	.1820	-.01431	1.0506
164	POOR FNC PLAN	.01133	.7295	.01988	.7321
	Constant	2.3834		2.4621	
	R-squared	.7696		.7918	
	F-Statistics	57.4900		20.7848	
	d.f. residual	568		153	
	Number of Cases	602		182	
	Standard Error	.0622		.0571	

TABLE 13A

The Coefficients and F-Statistics for the Reciprocal Distance Variable at Each Step During the Entry of Control Variables

Model 3: All Sales

Step #	Variable Entered	Coefficient for log d	F-Statistic for coefficient
1	FREEWAY BAD	.0870	8.012
2	log TOTL LIV AREA	.0962	19.968
3	log AGE SALE	.0771	17.491
4	N1	.0714	17.367
5	log LOT AREA	.0534	10.866
6	log RCN GAR	.0534	11.067
7	FAIR COND	.0515	10.466
8	EYR 35*41	.0477	9.080
9	THRU STREET	.0513	10.582
10	EYR 50*59	.0468	8.733
11	NO. FIREPLACES	.0464	8.680
12	CENTL HEAT	.0441	7.836
13	RUSTIC	.0459	8.445
14	EXTRA EQUIP	.0459	8.492
15	NUISANCE	.0482	9.243
16	BAD*LOCS	.0473	8.928
17	log RM AVG	.0470	8.839
18	DEAD END	.0489	9.513
19	SHINGLE	.0479	9.086
20	NO. BATHS	.0467	8.641
21	SLOPE	.0500	9.575
22	LEVEL	.0450	7.616
23	IMPS*NEW	.0431	6.867
24	VIEW	.0428	6.766
25	STREET PAVING	.0433	6.909
26	TOTAL ROOMS	.0437	7.024
27	POOR FNC PLAN	.0435	6.945
28	STEEP*DOWN	.0437	7.008
29	STREET SLOPE	.0440	7.059
30	FUNC PLAN	.0434	6.822
31	N2	.0402	4.485
32	MEDIUM TRAFFIC	.0394	4.239

TABLE 13B

The Coefficients and F-Statistics for the Reciprocal Distance Variable at Each Step During the Entry of Control Variables

Model 3: Post-1973 Sales

Step #	Variable Entered	Coefficient for log d	F-Statistic
1	FREEWAY BAD	.0562	.996
2	log TOTL LIV AREA	.0837	4.572
3	N1	.0733	4.317
4	log AGE SALE	.0538	2.640
5	log LOT AREA	.0458	2.054
6	NUISANCE	.0527	2.905
7	log RCN GAR	.0538	3.153
8	FIREPLACES	.0451	2.247
9	THRU STREET	.0469	2.507
10	EXTRA EQUIP	.0467	2.581
11	RUSTIC	.0551	3.603
12	FUNC PLAN	.0537	3.476
13	DEAD END	.0548	3.636
14	SLOPE	.0646	4.817
15	BAD*LOCS	.0597	4.091
16	FAIR COND	.0602	4.193
17	N2	.0737	5.591
18	CENTL HEAT	.0716	5.273
19	STREET SLOPE	.0663	4.350
20	HEAVY TRAFFIC	.0638	4.040
21	POOR FUNC PLAN	.0632	3.919
22	NO. BATHS	.0650	4.099
23	SHINGLE	.0623	3.677
24	MEDIUM TRAFFIC	.0614	3.543
25	STUCCO	.0628	3.668
26	LEVEL	.0597	3.201
27	STEEP ROOF	.0598	3.185

TABLE 14

Estimated Change in the Price Gradient and the Price of Single Family Houses Using Model 3

Distance	$d^{.0597}$	% Change in Price	Price Change*	$\frac{.0597}{d}$	Price Gradient*
500 ft	1.147	-7.9%	-$2,370	.00597	$179.1
1000	1.196	-4.0	-1,200	.002985	89.55
1500	1.225	-1.7	-510	.00199	59.7
2000	1.246	0	0	.00149	44.7

*The price change and price gradient is calculated for a house which would sell for $30,000 if it were located 2000 feet from the station. The price gradient describes the rate of increase in the sales price of a $30,000 house for each increase in 50 feet from the station.

the change in price of houses located at different distances from the BART station. The third column describes the percent of decrease in price relative to the price of houses located 2000 feet from the station. The fourth column describes the expected selling price at different distances of houses that would sell for $30,000 should they be located 2,000 feet from the station. The proportion prices change per 50 feet is described in the next column and the last one describes the rate at which sales prices increase for $30,000 houses located at different distances from BART.

The estimated magnitude of the estimated price drop for the average house using the log-linear model is approximately the same as that found by using the reciprocal transformation. The rate of change in the gradient, however, is slower and this may have improved the fit. While the multiple correlation coefficient and the F-statistic are slightly less for the multiplicative model, the estimates of the distance parameter show less variance and the confidence with which we can reject the null hypothesis increases.

The last model is used as a check. The sales price divided by the assessor's roll value are regressed against the distance and the control variables. The log-linear form is used. Since the appraisors do not believe that the Rockridge BART station has affected property prices, they do not adjust for this factor when determining the roll value of the house.

If we believe that the appraisers do not make systematic mistakes, that the proportion of assessed value to sales price is the same for all houses, then we can interpret the estimated coefficients for the variables describing each property as the degree to which BART has changed

prices across houses with different attributes. I do not hold this belief with sufficient conviction and therefore include the building and site attributes as control variables. Tables 15 and 16 present the regression results and again the null hypothesis is rejected in favor of the negative price impact alternative. Using a two-sided test the null hypothesis is rejected at the .02 significance level. The Rockridge BART station does indeed appear to have caused a decrease in the sales price of single family houses.

TABLE 15

Regression Results: Model 4
Log (Price/Roll) Against Log Transformations of Continuous Variables

		ALL SALES	
		Coef.	F-Statistic
154	$\log_{10} d$	.04545	5.7852
91	FREEWAY BAD	.01604	.4488
155	log LOT AREA	.02998	1.3868
156	log TOTL LIV AREA	.15112	.8575
157	log AVG RM AREA	-.13346	.6445
158	log AGE SALE	-.15009	312.6339
21	TOTAL ROOMS	-.00728	.3810
26	BATHS	-.01124	2.1422
30	GOOD CONDITION	-.00855	.6230
52	FIREPLACES	.00183	.0993
57	RUSTIC	-.01026	2.2076
69	DEAD END	-.03256	3.9699
72	STREET SLOPE	.01446	1.9513
74	THRU STREET	-.11085	10.9748
80	STREET LIGHTS	.01691	.6839
85	HEAVY TRAFFIC	.05641	2.6035
98	VIEW	.02060	1.9790
106	NUISANCE	-.00829	.6499
112	LEVEL	.00600	.3457
113	SLOPE	-.02234	2.6636
116	STEEP*DOWN	.03574	2.6148
125	IMPS*NEW	-.00676	0.1822
127	BAD*LOCS	.02568	2.8785
140	EYR 35*41	.02031	1.4762
161	N1 E OF COLLEGE	-.03170	15.8851
162	N2 NW OF STN	-.00781	.9408
	Constant	-.09290	
	R-Squared	.4108	
	F-Statistic	15.4184	
	Number of Cases	602	
	Standard Error	.0612	

TABLE 16

The Coefficients and F-Statistics for the Reciprocal Distance Variable at Each Step During the Entry of Control Variables

All Sales: Model 4

Step #	Variable #	Variable Entered	Coefficient for log d	F-Statistic
1	91	FREEWAY BAD	.0444	5.411
2	158	log AGE SALE	.0255	2.652
3	161	N2 E OF COLLEGE	.0282	3.427
4	116	STEEP*DOWN	.0310	4.116
5	69	DEAD END	.0340	4.914
6	57	RUSTIC	.0360	5.481
7	140	EYR 35*41	.0350	5.187
8	72	STREET SLOPE	.0326	4.438
9	113	SLOPE	.0364	5.392
10	155	log LOT AREA	.0355	5.116
11	80	STREET LIGHTS	.0366	5.417
12	98	VIEW	.0367	5.449
13	162	N3 NW OF STN	.0427	6.021
14	21	TOTAL ROOMS	.0451	6.537
15	26	NO. BATHS	.0459	6.767
16	30	GOOD COND	.0490	7.422
17	52	NO. FIREPLACES	.0493	7.506
18	74	THRU STREET	.0506	7.484
19	127	BAD*LOCS	.0457	6.381
20	85	HEAVY TRAFFIC	.0436	5.789
21	106	NUISANCE	.0456	6.178
22	112	LEVEL	.0432	5.383
23	156	log TOTL LIV AREA	.0443	5.552
24	125	IMPS*NEW	.0454	5.785

IV. CONCLUSIONS

1. The Qualifications

Econometric models were used to isolate that component of the sales price that can be fairly attributed to the presence of the Rockridge BART station. The observations used to test the hypothesis have come from a very special environment. The findings are the result of the economic conditions prevalent at the time the observations were taken, the attitudes of city officials and Rockridge residents, and the tastes, incomes, beliefs, expectations and the other housing options available to those involved in the transactions. These findings are therefore as unique to Rockridge as was its situation. When the findings are transferred out of this context they become in themselves only one new data point. No general statement regarding BART's impact on sales prices can be based on this study.

The models used in this study attempted to estimate the implicit price that people have paid for proximity to the BART station. By including a large set of control variables we attempted to draw away from the price-distance relationship any effect that is attributable to differences in the characteristics of the houses and their surroundings. Although we included a large number of control variables and gave 80 variables the chance to enter the regression equation, we cannot be sure that some specification error or some peculiarity in the relationship among the control variables led us to finding a negative price impact.

The BART lines run along the Grove-Shafter Freeway and the station is

at the crossroads of the freeway and the increasingly congested College Avenue. Parking lots were built under the freeway on both sides of College Avenue, extending the asphalt environment at grade level. A Lucky's supermarket and the Claremont Junior High School are located on the north side of the station. Categorical control variables were entered into the regression equation which identified the houses whose market value in the appraisor's opinion is detrimentally affected by the freeway, commercial uses, schools, heavy traffic and other nuisances. It is possible that the control variables were not adequately picking up the effect of the happenings around the station. The problem of omitted variables can always be raised. It is possible that some other than BART factor caused us to find a positive partial correlation between price and distance. This explanation is plausible, but to accept it we must explain why the use of Model 4 leads to the conclusions found by using the other equations. The roll value, the appraiser's estimate of the market value of the house, is included in the model and the magnitude of its coefficient was set equal to one. Model 4 can be rewritten as:

$$9. \quad P_i = c\, d_i^{\beta} * RV_i * \prod_{j=1}^{L} Q_i^{\alpha_i} * 10^{E_i}$$

The appraiser determines the roll value of houses by using both regression analysis and judgment. The roll value in itself should be picking up the obvious environmental impacts of schools, supermarkets and crowded streets, as well as those due to excessive depreciation, recent remodeling, type and condition of the structure, number of garages and so on. Since the appraiser does not believe that the Rockridge BART station has had a price impact, any impact which may have occurred is not

accounted for and its effect would be picked up by the distance and other housing attribute variables. We can believe that the Assessor may have inaccurately set the roll value, that relevant factors which are correlated with distance were omitted. If this were true, then the 22 variables entered into Model 4 can be seen as variables controlling for the possibility that the appriser made systematic errors in judgment. Even after the introduction of all these "control" variables along with the roll value, the estimated parameter for the distance variable supports the conclusion that a <u>relative</u> price decline occurred near the station during 1973 and 1974. Should this correlation be spurious, due to some omitted variable, then the variable is one which the Alameda County Assessor's Office has not included in its data base <u>and</u> one which does not enter into the Alameda County Assessor's judgment when setting the roll value of houses.

2. The Explanations:

All the statistics presented in this paper are consistent with the conclusion that the Rockridge BART station, rather than being the boon to home-owners, reduced their valuation of proximate locations and caused a small <u>relative</u> decrease (less than 8%) in the sales price of the houses. The findings also indicate that the decrease has been greater during the post-January 1973 period than it was during the earlier one. Because the major impact on the physical environment occurred in the mid-sixties during the construction of the BART and freeway complex and because BART's advantage was felt only after its opening in 1973; the cause of the depression in the price gradient cannot be easily explained by changes in the physical environment brought about by the construction and the presence of the

BART-freeway complex. Should the physical presence of the station and the freeway with its fumes and noise have been the single major factor causing the price decrease, then surely the price decline would have started during the construction period and reached an equilibrium shortly after the freeway opened.

One plausible and reasonable explanation of the finding is based on the uncertainty residents and investors may have had regarding the future of Rockridge. In 1969 the Oakland City Planning Department predicted a great development potential for the Rockridge station area. This prediction was not going to induce homeowners to seek sites near the station. A strong and publicized concern for the future of Rockridge as a single-family environment emerged in the early seventies. It is possible that people who considered several Rockridge locations, considered the potential impact and preferred the more distant houses. In 1974 and 1975, when citizen group protests were being heard by city officials and publicized in the local paper, potential developers and investors may have held off to wait for the turmoil to settle: opposing an active, well organized citizenry is a risky and costly business. The relative price decline may have been caused by residents fearing the development potential and developers fearing the residents.

3. The Conclusions:

The strength of the conclusions we draw depends on our prior belief as to what really happened. I am convinced as a result of this investigation that the Rockridge BART station did not cause the sales price of houses to increase during the 1968-1975 period. The findings certainly support

the conclusion that any positive change due to the access improvement was at least equally counteracted by associated non-physical environmental impacts. The findings support the conclusion that the non-physical, environmental impacts caused a net decline in sales prices. This belief could be strengthened by a more thorough analysis than was possible of the estimated distance parameter's sensitivity to changes in the perimeter of the study area.

The fact that the station did not increase property prices in its vicinity suggests, though inconclusively, that no major imminent changes in the housing stock were about to occur. Had BART made Rockridge "one of the most attractive areas to investors in residential buildings," then it appears that these investors found Rockridge attractive in ways that did not encourage them to compete for land and drive up its price. The downzoning decision does not appear to have caused the City of Oakland to have missed any great opportunity to increase its tax base at this point in time. The lack of competition for sites indicates that investors in residential buildings did not at this point in time anticipate the immediate emergence of a large demand for Rockridge locations. People who bought houses did not consider the travel time savings a proximate house offered to be worth more than the other conditions affecting such houses.

If the expectations of the residents regarding the great BART development potential along with the uncertainty caused by citizen group reactions to the potential impact, then the downzoning decision of 1974-1975 should restore the residents' faith in the future of Rockridge and cause the slight depression in the price gradient to disappear.

APPENDIX

A DESCRIPTION OF THE VARIABLES IN THE ALAMEDA COUNTY TAX ASSESSOR'S MACHINE-READABLE FILES ON SINGLE-FAMILY HOUSES

Table A2

Definition of Variables on Which Data is Available

Assessor's Variance Number	Assessor's Mnemonic Name	Definition
1	RES RCN	Replacement cost new of structure
2	RE.RCNLD	Replacement cost less depreciation
3	RCN TF2	Replacement cost new of living area
4	RCN GAR	Replacement cost new of garage
5	OTHER RCN	Replacement cost new of other than living area or garage
6	TOTL FT2	Total square foot area of building
7	FT2 1ST	Area of first floor
8	FT2 2ND	Area of second floor
9	FT2 BSM	Area of basement
10	FT2 3RD	Area of third floor
11	FCV LAND	Assessor's estimation of the value of the land residual
12	FR WIDTH	Front width of lot
13	RE WIDTH	Rear width of lot
14	DEPTH	Depth of lot
15	ACT AREA	Actual area of lot
16	USA AREA	Useable area of lot
17	CLASS	Quality class of structure
18	PCTGD CT	Difference between normal percent of structure that is good for house of that age and class and the actual percent that is good. This variable is used in computing replacement cost less depreciation

Table A2, Continued

Assessor's Variance Number	Assessor's Mnemonic Name	Definitions
19	YEARS BUMP	Years the actual age of building is adjusted upward to compute the effective afe of building which accounts for remodeling.
20	AGE BLDG	Effective age of building
21	TOT RMS	Total number of rooms
22	FIXTURES	Number of plumbing fixtures in the building
23	STORIES	Number of stories in building
24	MEIGBOR	Sub-neighborhood code
25	USE CODE	Land use code, all single family on tape
26	BATHS	Number of bathrooms
27	SHAPE	Shape class of lot
28	SPLT LEV	Split level building
29	UNITS/PA	Number of units on parcel
30	GOOD CON	Above average in condition of building for age and class of structure
31	FAIR CON	Below average condition
32	DEF MAIN	Seriously undermaintained
33	FUNC PLN	Plan deemed functional
34	BEDRMS	Number of bedrooms
35	DINE RM	Dining room type
36	FAM*RM	Family room present
37	UTIL-LND	Degree of land utilization by neighborhood standards

Table A2, Continued

Assessor's Variance Number	Assessor's Mnemonic Name	Definitions
38	MIN REMD	Minimum remodeling present
39	MAJ REMD	Major remodeling present
40	BSMT FIN	Finished basement present
41	BSMT APT	Basement apartment present
42	ADDITION	Addition to house present
43	NO*GAR	Number of garages
44	BSMT GAR	Basement garage present
45	ATT GAR	Attached garage present
46	DET GAR	Detached garage present
47	GAR CON	Garage conversion present
48	CARPORT	Carport present
49	HEATING	Type heating system
50	CEN HEAT	Central heating present
51	COOLING	Cooling system present
52	FIREPLC	Number of fireplaces
53	ONE+FPLC	One or more fireplaces present
54	XTRA EQU	Number of pieces of extra equipment such as ranges, ovens, refrigerators, dishwashers, etc.
55	STUCCO	Stucco exterior finish
56	SHINGLE	Shingle exterior finish
57	RUSTIC	Rustic appearance of building
58	EXT COVER	Type of exterior cover

Table A2, Continued

Assessor's Variance Number	Assessor's Mnemonic Name	Definitions
59	FLT ROOF	Felt roof finish present
60	STP ROOF	Slope of roof
61	ROOF COV	Type of roof cover
62	SWM POOL	Swimming pool present
63	UNDR IMP	Identifies under improvements as determined by the assessor's judgment of the building and its environs.
64	OVER IMPR	Identifies over improved propoerties
65	EXCS LND	Excess land
66	SITES	Identifies sites on which an extra improvement can be added
67	IRREG	Irregular lot shape
68	CORNER	Parcel on block corner
69	DEAD END	Parcel on dead end street
70	CUL-DE-S	Parcel at end of Cul-de-Sac
71	EASEMENT	Identifies innocuous, detrimental or beneficial easements
72	ST. SLOPE	Street slope
73	ST. FRONT	Street frontage
74	THRU ST.	Thru street frontage
75	DBL. ACC	Double access to parcel
76	CURB/GUT	Curbs and gutters
77	SIDEWALK	Describes adequacy of sidewalk
78	BLVD. STR	Boulevard strip

Table A2, Continued

Assessor's Variance Number	Assessor's Mnemonic Name	Definitions
79	PAVED ST	Identifies narrow streets, i.e., hillside streets
80	ST. LIGHT	Street lighting proper
81	PARKING	Adequacy of parking
82	WATER FR	Water front
83	WT. FT. QU	Water front quality
84	MED TRAF	Medium traffic
85	HVY TRAF	Heavy traffic
86	TRU*MED	Street and traffic interaction variable
87	TRU*HVY	Street and traffic interaction variable
88	NTHR*MED	Street and traffic interaction variable
89	NTHR*HVY	Street and traffic interaction variable
90	FREEWAY	Describes proximity to freeway
91	FRWY BAD	Too close to freeway; identifies freeway nuisance
92	UTIL. LIN	Utilities lines
93	WATER	
94	SEWER	
95	STORM DR	Storm drains
96	ZONING	Zoning code entry
97	ZON. CONF	Identifies buildings in conformity with zoning and those which are under and over
98	VIEW	Identifies view possibility

Table 2A, Continued

Assessor's Variance Number	Assessor's Mnemonic Name	Definitions
99	VIEW QUA	View quality
100	VIEW UTL	Identifies houses with the view being utilized
101 - 105		Identifies direction of view
106	NUISANCE	Three categories of nuisance, 0; moderate nuisances 1; strongly detrimental nuisances 2. Any nuisance except ones caused by the proximity to the facilities described by the following variables may be considered.
107	SCHOOL	Three categories: within walking distance 0; outside walking distance 1; too close for comfort 2.
108	SHOPPING	Three categories for shopping facilities
109	REC	Three categories for recreation facilities
110	NOT M&B	Building deemed not to be of the highest and best use of land when compared to neighborhood standards
111	NOT REP	Building is not representative of buildings in immediate area
112	LEVEL	Identifies level lots
113	SLOPE	Identifies sloped lots, level 0; medium 1; steep 2.
114	DIRECTN	Identifies direction from street of slope
115	STPXUP	Identifies steep sloped lots with slope going up from street.
116	STPXDN	

Table 2A, Continued

Assessor's Variance Number	Assessor's Mnemonic Name	Definitions
117	STP*SIDE	
118	MED*UP	
119	MED*DN	
120	BANK	Identifies properties where the building is located on a cut or hill
121	RET. WALL	Identifies retaining walls
122	ACCESS	Degree of difficulty of accessing the building from the street
123	IMM. AREA	Identifies houses next to spotted commercial property
124	IMP. OLD	Identifies buildings older than typical in neighborhood
125	IMP. NEW	Identifies newer than typical buildings
126	BAD*IMP	One or more extreme characteristics involving the property improvement. Includes: Non representative, deferred maintenance, poor building access, under improvement, and saleable site
127	BAD*LOC	One or more extreme characteristics involving the property location. Includes: thru street, heavy traffic, too close to freeway, zoning non-conforming, too close to schools, too close to shipping, too close to recreation, not highest and best use, immediate area.
128	BAD*BAD	Combination of the bad location and bad improvement variables, shows one or more count
129	VAR 619	Spots building assessment problems codes; 1. Architecture extremely attractive 2. Spanish style architecture 3. English style architecture (Tudor, half timber)

Table 2A, Continued

Assessor's Variance Number	Assessor's Mnemonic Name	Definitions
		4. Extreme defect maintenance 5. "Moved on" building inadequately patched up 6. Inharmonious architectural style 7. Total remodeling 8. Priced in field
130	VAR 621	Identifies dual land-use of site land
131	VAR 620	Identifies 14 categories of land problems. Category #5 is "BART's Positive Influence"
132	AGE SALE	Number of months ago from current (July 1975) that sale took place
133	SALES PRICE	Sales price of sold houses

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